

# ESSAYS ON MACROECONOMIC ASPECTS OF FISCAL POLICY

A Dissertation

by

Wongi Kim

Submitted to the Office of Graduate and Professional Studies of  
Texas A&M University  
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Chair of Committee,	Ryo Jinnai
Committee Members,	Sarah Zubairy
	Yuzhe Zhang
	Hwagyun Kim
Head of Department,	Timothy Gronberg

August 2015

Major Subject: Economics

Copyright 2015 Wongi Kim

## ABSTRACT

Recently, various fiscal policies are adopted to overcome severe recessions caused by the Financial Crisis and the Great Recession in many advanced countries. In this dissertation, I focus on the effects of those various fiscal policies on the aggregate economy.

In the first study, I examine the state-dependent effects of government debt on government spending multipliers. First, I estimate the spending multipliers conditional on the level of government debt using US historical data and the two-state direct projection method. The empirical results show that the estimated short-run multipliers in a high debt state are larger than those in a low debt state, which contradicts to the conventional prediction. Second, I find evidence to support that the government spending significantly differs by the level of government debt. To understand large short-run multipliers in a high debt state, I construct a New Keynesian model to explain the large short-run multipliers in a high debt state. The model suggests that the interaction between the state-dependent government spending rule and monetary policy could be a potential channel to understand the large short-run multipliers in a high debt state.

In the second study, I investigate the time-varying relation between government budget balances and external balances to test the twin deficit hypothesis. Through a time-varying structural VAR model and the post World War II data for the US economy, I find new time-varying patterns. To provide some insights about the empirical facts, I construct a small open economy New Keynesian model incorporated rule-of-thumb consumers suggested by Gali et al. [2007b]. A shift in exchange rate regimes and slow-adjusting taxes seem to be useful to understand the empirical results.

## DEDICATION

To my parents and my wife

## ACKNOWLEDGMENTS

First, I would like to express my deepest gratitude to my advisor Dr. Ryo Jinnai. Without his support and encouragement, I might not have finished this dissertation. I specially thank Dr. Sarah Zubairy for her guidance and support on my dissertation. I would also like to thank Dr. Yuzhe Zhang and Dr. Hwagyun Kim for their advice and serving as my committee members. I really appreciate for their insightful suggestions.

A very special thanks goes out to Dr. Noh-Sun Kwark, without whose support and help I would not have decided to have a graduate career in economics research. Dr. Noh-Sun Kwark is my advisor in my master program. He truly gives me priceless support.

I would like to give special thanks to my family. Words cannot express how grateful I am to my parents, Hee-doo Kim and Soon-im Jang. Without their support and dedication, I might not have finished this long journey. I would also like to thank my mother-in-law, Hyun-duk Song. She has always supported and encouraged me with best wishes. Finally, I would like express specially appreciation to my wife, Seungyeon Oh. My life is plenty of happiness because of your being. I love you.

## TABLE OF CONTENTS

CHAPTER		Page
I	INTRODUCTION .....	1
II	GOVERNMENT SPENDING MULTIPLIERS AND PUBLIC INDEBTEDNESS: AN INVESTIGATION FOR THE U.S. ....	4
	II.1 Introduction .....	4
	II.2 Data and Econometric Method .....	11
	II.2.1 Data .....	11
	II.2.2 Econometric Method .....	12
	II.3 Baseline Results .....	17
	II.4 Robustness .....	21
	II.4.1 Robustness: Different Time Trend, Thresholds, and Other Specifications .....	22
	II.4.2 Robustness: Control Tax Policy .....	24
	II.5 The Large Short-run Multiplier in a High Debt State: A New Keynesian Lens .....	27
	II.5.1 The Model .....	28
	II.5.2 Calibration .....	33
	II.5.3 The Impulse Response Analysis .....	34
	II.6 Concluding Remarks .....	37
III	STRUCTURAL CHANGES? FISCAL POLICY AND TWIN DEFICITS IN A TIME VARYING STRUCTURAL VAR .....	40
	III.1 Introduction .....	40
	III.2 Data, Econometric Method, and Identification .....	45
	III.2.1 Econometric Method .....	45
	III.2.2 Estimation Method .....	48
	III.2.3 Data .....	50
	III.2.4 Identification and Interpretation .....	51

CHAPTER	Page
III.3 Estimation Results .....	54
III.3.1 Preliminary Evidences on Structural Breaks: Sub-sample Analysis .....	54
III.3.2 Unveiling Time Variation: Time Varying Structural VAR .....	56
III.4 Discussion .....	58
III.4.1 Theoretical Model .....	59
III.4.2 Calibration .....	67
III.4.3 Floating Exchange Rate Regime versus Fixed Exchange Rate Regime .....	68
III.4.4 The 1980s Anomaly .....	72
III.5 Concluding Remarks .....	74
IV CONCLUSION .....	75
REFERENCES .....	77
APPENDIX A .....	90
APPENDIX B .....	98

## LIST OF TABLES

TABLE		Page
1	Explanatory Power of the Defence News Variable .....	98
2	Robustness: Different Time Trends, Thresholds, and Other Specification .....	99
3	Calibration .....	100
4	Data Source .....	101
5	Detailed Data Source of US Gross Federal Debt .....	102
6	Calibration .....	103

## LIST OF FIGURES

FIGURE	Page
1 Debt-to-GDP Ratio and News Variable .....	104
2 Impulse Response in the Linear Model .....	105
3 State-dependent Impulse Response .....	106
4 Cumulative Multipliers .....	107
5 Impulse Response in the Linear Model with Tax Rates .....	108
6 State-dependent Impulse Response with Tax Rates .....	109
7 The Ratio of Cumulative Tax Receipts to Cumulative Government Spending .....	110
8 Cumulative Multipliers .....	111
9 Selected Impulse Responses to a Defense News Shock .....	112
10 Selected Impulse Responses to a Defense News Shock: Non-linear	113
11 Impulse Response of Selected Variables in Sub-sample VAR .....	114
12 Median Response of NX to Government Spending .....	115
12 Median Response of NX to Government Spending: 3D-plot .....	116
14 Median Response of Terms-of-trade to Government Spending ....	117
15 Median Response of Terms-of-trade to Government Spending : 3D-plot .....	118
16 Median Response of GDP to Government Spending .....	119
17 Median Response of GDP to Government Spending: 3D-plot .....	120
18 Median Response of Government Spending to Government Spending	121
19 Median Response of Government Spending to Government Spending : 3D-plot .....	122



FIGURE		Page
20	Impulse Response of Selected Variables to Government Spending Shock under Different Exchange Rate Regime .....	123
21	Impulse Response of Selected Variables to Government Spending Shock with Slow-Adjusting Taxes .....	124

## CHAPTER I

### INTRODUCTION

This dissertation investigates macroeconomic aspects of fiscal policy. Fiscal policy has recently attracted renewed attention since various fiscal tools have been adopted to stimulate the economy in many countries during the recent severe recession. Furthermore, the effects of fiscal consolidation on the economy are currently actively discussed, since many advanced countries suffer from high levels of government debt. However, no consensus on the effects of fiscal policy has been reached. This dissertation aims to contribute to this ongoing debate on the effects of fiscal policy using various empirical methods and simple theoretical models to provide potential channels to understand the empirical results.

In the second chapter, “Government spending multipliers and public indebtedness: an investigation for the US,” I examine whether government spending multipliers vary depending on the level of government debt.<sup>1</sup> In the aftermath of the financial crisis and the Great Recession, many advanced countries raised government spending financed by debt to boost private activity and therefore government debt levels sharply escalated. However, a strand of theoretical literature argues that an increase in government spending could be contractionary when the debt levels exceed some threshold. This is because a high level of government debt could lead a rise in interest rate through sovereign default risks and low future disposable income through increases in future distortionary taxes due to the tightly binding government budget constraint. According to this view, multipliers in a high debt state are smaller than those in a low debt state and could even be negative. If multipliers are less than unity, government spending is unlikely to stimulate private activity. If

multipliers are negative, recent fiscal consolidation in many advanced countries is not necessarily accompanied by economic downturns.

To contribute to this important policy-related question, this paper estimates spending multipliers conditional on the level of government debt using estimated state-dependent impulse responses based on the average behavior of the economy in each state. For the estimation, a new quarterly US historical debt series from 1890 to 2010 is constructed. Two important results are obtained. Two important empirical results arise. First, the estimated multipliers significantly differ by the level of debt. Surprisingly, the estimated short-run multipliers in a high debt state are larger than those in a low debt state, which is contrary to the conventional prediction. Second, I do not find strong evidence to support a large increase in distortionary taxes, and a sharp rise in interest rate in a high debt state. The responses of 10-year government bond interest rate do not statistically differ across states. Furthermore, the calculated tax fraction of government spending does not seem to provide strong evidence to support that the government may prefer tax-financed spending in a high debt state. Instead, I find some evidence to support that the government may try to stabilize debt levels by limiting debt-financed spending and subsequent future spending cuts below the trend in a high debt state. The responses of government spending, and debt in a low debt state are strongly positive, whereas those in a high debt state are weak and turn negative at some point. To understand large short-run multipliers in a high debt state, I suggest a simple New Keynesian model. The previous theoretical studies focus on the role of future taxes to stabilize debt levels and ignore the role of future spending cuts. However, the model shows that the state-dependent government spending rule in which spending cuts in response to a rise in debt take place more strongly in a high debt state could be a potential candidate to understand the large short-run multiplier in a high debt state.

In the third chapter, “Structural changes? Fiscal policy and twin deficits in a time varying structural VAR,” I investigate the time-varying effects of government budget balances on trade balances. In the aftermath of the financial crisis and the Great Recession, many developed and developing countries suffer from huge budget deficits and external deficits, and a number of countries have faced the challenge of reducing both budget deficits and external deficits. In fact, the challenge is closely related to the twin deficit hypothesis: budget deficits cause external deficits. Although the hypothesis has important policy implications for recent economic situations, previous studies provide somewhat mixed evidence on this issue. Furthermore, a large number of studies detect structural changes in the relation between budget balances and external balances, but the previous quantitative studies on this issue ignore the effects of those structural breaks.

To evaluate the time-varying relation between budget balances and external balances, I estimate a time varying structural vector autoregressive model using post-World War II US data. The following four empirical results arise: (1) In the Bretton Woods era, an exogenous increase in government spending and consequent budget deficits lead trade deficits. (2) Conversely, an increase in government spending induces trade surpluses in the post-Bretton Woods era. (3) Anomaly in the 1980s: trade deficits are caused by an increase in government spending in the 1980s in spite of the adoption of a floating exchange regime in the US. (4) The response of terms-of-trade is stable for the entire periods: Appreciation (increase in the real value of the dollar) after an initial small depreciation. To provide some insights about empirical results, I construct a small open economy New Keynesian model incorporating rule-of-thumb consumers suggested by Gali et al. (2007). A shift in exchange rate regimes seems to be useful to understand the results (1) and (2). Slow-adjusting taxes seem be useful to understand the result (3).

## CHAPTER II

### GOVERNMENT SPENDING MULTIPLIERS AND PUBLIC INDEBTEDNESS: AN INVESTIGATION FOR THE U.S.\*

#### II.1 Introduction

In the aftermath of the financial crisis and the Great Recession, many advanced countries increased government spending to boost private activity. These increases in spending were mainly financed by debt and therefore government debt levels sharply escalated. In the US, for example, the gross federal debt-to-GDP ratio rose from 60% in 2007 to 90% in 2010. In this circumstance, questions naturally arise: do government spending multipliers vary depending on the level of government debt? If so, which channel drives those relations?

The conventional wisdom argues that spending multipliers become smaller or could even be negative when a level of debt exceeds some threshold. They suggest two potential channels: the interest rate channel, and the distortionary tax channel. If a level of government debt exceeds a threshold and sovereign default risks sharply increase, interest rate also sharply increases. This high level of interest rate possibly offsets stimulus effects of government spending. Furthermore, fiscal adjustments by increasing in future distortionary taxes are likely to take place in a high debt state due to the tightly binding government budget constraint. In this circumstance, households would increase precautionary savings rather than consumption due to expected low future disposable income caused by that increase in future distortionary

---

\*Part of this chapter is reprinted with permission from “Do government spending multipliers depend on the level of government debt? US historical data evidence” by Wongi Kim, 2015. Applied Economics Letters, 22(8), 668 - 672, Copyright [2015].

taxes, which could reduce spending multipliers in a high debt state.<sup>1</sup> If spending multipliers are below unity due to the high level of debt, an increase in government spending is not an efficient way to stimulate private activity in a high debt state.

In contrast to this conventional prediction, this paper argues that spending multipliers could be larger when the debt-to-GDP ratio exceeds a threshold, at least, in short run. To this end, I provide some empirical and theoretical evidence to support the claim. In the empirical part, I estimate the spending multipliers conditional on the level of government debt using the defense news variable proposed by Ramey [2011a] to identify a spending shock, a newly constructed US historical quarterly debt data from 1890.Q1 to 2010.Q4, and the two-state direct projection method. The results provide some favor evidence to support the claim. In the theoretical part, I construct a closed economy New Keynesian model to propose a potential channel to explain the large short-run multipliers in a high debt state.

A key in the construction of spending multipliers is identifying an exogenous and unanticipated spending shock. To this end, I use the narrative approach using the defense news variable. Previous studies on this issue such as Ilzetzi et al. [2013] mainly use the standard vector autoregression (VAR) model proposed by Blanchard and Perotti [2002] to identify a spending shock. As shown in Ramey [2011a], however, this method may fail to identify a proper spending shock since changes in government spending are well anticipated long before spending actually changes by private agents in the economy, and the standard VAR may not properly capture this anticipation. The defense news variable focuses on the expected discounted value of government spending changes related to foreign political or military events, so that it is unlikely to be related to the economic fundamentals and is unanticipated. Thus the narrative

---

<sup>1</sup>See Bi [2012] and Corsetti et al. [2013] for the interest rate channel. See Bertola and Drazen [1993] and Perotti [1999] for the tax channel. Ilzetzi et al. [2013] and Baumeister and Peersman [2013] provide some empirical evidence to support this view.

approach using the defense news could help mitigate the bias caused by private agents' anticipation of future spending changes. However, it is not straightforward to use this narrative approach with the existing short time series of debt. The estimation using the defense news could be interpreted as an instrumental variable approach and therefore the relevance of defense news for changes in government spending is important. As shown in Ramey [2011a], however, the defense news variable would not be a proper instrument in periods after the Korean War.<sup>2</sup> To overcome the problem, I construct a new quarterly US historical government debt series. Additionally, the sample periods cover World War II (WWII), in which historical US government debt peaks, so that I can utilize richer variations than previous studies.

Through the two-state local projection method similar to Auerbach and Gorodnichenko [2011], I obtain two important empirical results. First, the spending multipliers in a high debt state are larger than those in a low debt state, at least, in short-run. Second, I do not find strong evidence on a large increase in distortionary taxes and a sharp rise in interest rate in a high debt state, which are potential candidates to reduce spending multipliers in a high debt state. The responses of 10-year government bond interest rate, an indicator of sovereign default risks, do not statistically differ across states. Furthermore, the calculated tax fraction of government spending does not seem to be strong evidence to support that the government may prefer tax-financed spending in a high debt state. Instead, I find some evidence to support that the government may try to stabilize debt levels by limiting debt-financed spending and subsequent future spending cuts below the trend in a high debt state. The responses of government spending and debt to a spending shock in a low debt state are strongly positive, whereas those in a high debt state are weak

---

<sup>2</sup>Intuitively, this identification strategy depends on the major war events such as World War I, World War II, and the Korean War, so that a long time series is necessary to utilize enough variations.

and turn negative at some point.

To understand the large short-run multipliers in a high debt state, I construct a simple New Keynesian model. The previous theoretical studies focus on the role of taxes to stabilize debt levels and ignore the role of government spending. However, the empirical results support that the government spending heavily depends on the level of government debt. In particular, an increase in government spending is accompanied by future spending cuts in response to a rise in debt in a high debt state. However, those future spending cuts are not observed in a low debt state. Based on this finding, I introduce a state-dependent government spending rule in the standard New Keynesian. In the model, future spending cuts in response to a rise in debt are assumed to take place only when the level of debt is sufficiently high. Those planned future spending cuts in a high debt state could reduce future inflation and, via monetary authority's reaction function, future real interest rate. Since households anticipate lower future real interest rate, they increase their current consumption through the intertemporal substitution mechanism, which could magnify short-run stimulus effects. However, because future spending cuts do not take place in a low debt state, government spending crowds out households consumption through the interest rate channel. This result may imply that future spending cuts in response to a rise in debt in a high debt state and interaction between those spending cuts and monetary policy could be a key to generate the large short-run multipliers in a high debt state.

There are several studies on the state-dependent effects of government debt on spending multipliers. On the theoretical side, the conventional wisdom argues that spending multipliers in a high debt state are smaller than those in a low debt state because of large distortions induced by distortionary taxes. For example, Perotti [1999] shows that an increase in government spending could reduce aggregate con-



sumption when the initial level of debt is high. In his model, an increase in government spending increases the consumption of liquidity constrained households. At the same time, that increase in government spending reduces the consumption of liquidity unconstrained households since they expect low future disposable income due to an increase in future distortionary taxes. When the initial level of debt is low and distortion are sufficiently small, an increase in government spending increases aggregate consumption. However, if the initial level of debt is high, so are tax distortions, aggregate consumption could be negative. Bertola and Drazen [1993], and Sutherland [1997] also provide similar theoretical predictions. In addition, Bi [2012], and Corsetti et al. [2013] propose an alternative channel, the so-called sovereign risk channel. They show that an increase in spending in a high debt state could lead a sharp rise in interest rate and private funding costs via an increase in sovereign default risks, which possibly offsets stimulus effects.

Moreover, recent empirical studies provide some evidence on state-dependent effects of debt on spending multipliers.<sup>3</sup> Ilzetzi et al. [2013] show that the spending multipliers in high debt periods are negative and smaller than those in low debt periods regardless of horizons using country panel data and the structural VAR (SVAR) model. Baumeister and Peersman [2013] show the similar results using panel data on the Euro countries and a panel VAR model. Hernández de Cos and Moral-Benito [2013] also conclude that the spending multipliers in a high debt state are smaller than those in a low debt state using a smooth transition VAR (STVAR) and

---

<sup>3</sup>In this paper, I focus on the state-dependent effects of debt on spending multipliers, but a growing body of empirical literature shows that spending multipliers depend on various economic conditions. For example, Auerbach and Gorodnichenko [2011], Auerbach and Gorodnichenko [2012], Fazzari et al. [2013], Baum et al. [2012], Owyang et al. [2013], and Ramey and Zubairy [2014] investigate spending multipliers that depend on business cycle conditions. Ramey and Zubairy [2014] also consider the effects of the zero lower bound. Corsetti et al. [2012b], Ilzetzi et al. [2013], and Born et al. [2013a] estimate the effects of exchange rate regimes on multipliers. Ilzetzi et al. [2013] also consider openness to trade. Corsetti et al. [2012b] consider the effects of financial crises.

Spain data. Auerbach and Gorodnichenko [2011] show that the spending multiplier in a recession with the high level of debt is smaller than that in a recession with the low level of debt using OECD data. However, neither of them provides a specific channel to understand the state-dependent effects of debt on spending multipliers. In contrast to these studies, Corsetti et al. [2012b] show a little bit different result. They estimate several types of state-dependent spending multipliers using OECD panel data and a two-step econometric procedure to identify a spending shock. Their findings reveal that the spending multipliers in the “weak public finance state” (the debt-to-GDP ratio exceeds 100% or the deficit-to-GDP ratio exceeds 5%) are not different from those in the “normal state”. Furthermore, their results show that the response of consumption in the “weak public finance state” is positive, whereas that in the “normal state” is negative, which is sharply contrary to the conventional wisdom as shown in Perotti [1999].<sup>4</sup>

Although these empirical studies provide some evidence on the question, the method to identify a spending shock is up for debate. Most of the empirical studies regarding this issue use the SVAR approach to identify a spending shock.<sup>5</sup> After the pioneering studies by Blanchard and Perotti [2002] and Fatás and Mihov [2001], the SVAR model has been widely adopted to measure fiscal multipliers. In the SVAR model, government spending is assumed to be predetermined within the quarter. Under this assumption, the residuals of government spending from a regression of government spending on its own lags and lags of other variables in the VAR could be

---

<sup>4</sup>There is a strand of empirical literature which emphasizes the impact of debt on government spending using a linear framework. For example, Favero and Giavazzi [2007], and Chung and Leeper [2007] show that debt plays an important role in determining the effects of government spending on the economy. However, they do not consider the state-dependent effects of government debt.

<sup>5</sup>An exception is Auerbach and Gorodnichenko [2011]. They identify a spending shock using the forecasting errors of government spending. This method could mitigate the effects of private agents’ anticipation of future spending changes. Corsetti et al. [2012b] use a two-step procedure to identify a shock, but the meaning of this identification method is not different from the SVAR approach because a spending shock is identified by conditioning on past information.

interpreted as a structural spending shock, and the identification is easily achieved by placing government spending first in the VAR and the Choleski decomposition.<sup>6</sup> This identification strategy is easily implemented and widely adopted, but it is not uncontroversial. Ramey [2011a] points out that the government spending shocks identified by the SVAR are predictable and well anticipated by the private agents in the economy, which could lead us to reach incorrect conclusions because anticipated policy changes have somewhat different consequences compared with unanticipated policy changes. Taylor [1993] shows how differently the economy responds to anticipated changes and unanticipated changes in monetary policy and fiscal policy. Auerbach and Gorodnichenko [2012] show that controlling for predictable components of fiscal shocks tends to increase the size of the multipliers. Leeper et al. [2013] also show, using a theoretical model, that it is not easy to recover the true structural policy shock using standard VAR methods when private agents in the economy anticipate future policy changes. To mitigate this bias, Ramey [2011a] proposes the narrative approach using the defense news variable.<sup>7</sup> This identification method is adopted by Hall [2009], Barro and Redlick [2011], and Ramey and Zubairy [2014] to estimate US spending multipliers. Particularly, Ramey and Zubairy [2014] estimate state-dependent spending multipliers using US historical data and the narrative approach, which is similar to this work. However, they focus on whether the economy has slack or not, and the nominal interest rate zero lower bound, and do not consider debt-related issues.

---

<sup>6</sup>Ramey [2011b] provides a summary of the results in the literature that use the SVAR model.

<sup>7</sup>There are other methods to identify a spending shock. For example, Mountford and Uhlig [2009] use a sign restriction to identify a spending shock. Fisher and Peters [2010] construct a narrative record to identify a spending shock using the stock returns in the US.

## II.2 Data and Econometric Method

In this section, I provide detailed descriptions of data and econometric methods. Section II.2.1 refers to a description of data and section II.2.2 explains econometric methods.

### II.2.1 Data

The main question addressed in the paper is whether government spending multipliers depend on the level of government debt. To answer this question, I estimate state-dependent effects of government debt on spending multipliers using US historical data constructed by Owyang et al. [2013] and Shiller [2005] except the data on government debt. The data constructed by Owyang et al. [2013] covers several macroeconomic variables such as government spending, GDP, GDP deflator, population and the defense news variable from 1890 to 2010 at quarterly frequency. Particularly, the defense news variable is the extended series of Ramey [2011a]’s news variable. For interest rate, I use the series of 10-year government bond interest rate constructed by Shiller [2005].<sup>8</sup> Note that the government spending data constructed by Owyang et al. [2013] includes government consumption, and investment and does not include government transfer payments.

One of the contributions of this paper is constructing a new quarterly US government debt series from 1890.Q1 to 2010.Q4 based on two sources: monthly statement of public debt and treasury bulletin. Both of them are issued by the US treasury. Appendix B refers to a detailed description of the construction process, but I highlight some features of the US government debt constructed here. The government debt constructed here is the gross federal debt which is the broadest measure of gov-

---

<sup>8</sup>Perotti [2004] points out that long-term interest rate is arguably more important to determine private consumption and investment than short-term interest rate.

ernment debt. The series includes debt held by public and debt held by trust funds such as the Social Security Trust fund. Cashell [2010] claims that debt held by public is more relevant to measure the burden of government debt than gross debt since all gross debt, especially debt held by trust funds, do not represent past borrowing in credit markets. However, the debt held by public series is not available for entire sample periods. Moreover, the debt limit in the US is determined based on gross debt, not debt held by public, and several studies such as Reinhart and Rogoff [2010] also use gross debt as a measure of government debt in their research. Thus gross debt could be a reasonable measure of the burden of government debt. Furthermore, quarterly data is more relevant to capture sudden changes of the state of the economy than annual data since government debt sometimes increases sharply.<sup>9</sup> Additionally, annual data is not free from the private agents' anticipation even though a shock is identified by the defense news, as pointed out in Ramey [2011a]. Thus high frequency data is more useful to measure multipliers.

## II.2.2 Econometric Method

Following Auerbach and Gorodnichenko [2011] and Owyang et al. [2013], I employ Jordá [2005]'s local projection method to estimate state-dependent impulse response functions. The local projection method enables me to draw impulse responses directly by estimating a series of linear regressions for each impulse response horizon  $h$  for each variable of interest. Consider the following state-dependent model in which responses vary across states.

---

<sup>9</sup>For example, the debt-to-GDP in 1942.Q1 was 40%, but that rose 80% in 1943.Q3.

$$\begin{aligned}
y_{t+h} = & \gamma_{2,h}t + \gamma_{3,h}t^2 + \gamma_{4,h}t^3 + I_{t-1} \left[ \gamma_{1,h}^H + \sum_{i=1}^j A_{i,h}^H x_{t-i} + \beta_h^H shock_t \right] \\
& + (1 - I_{t-1}) \left[ \gamma_{1,h}^L + \sum_{i=1}^j A_{i,h}^L x_{t-i} + \beta_h^L shock_t \right] + \varepsilon_{t+h}, \quad h = 0, 1, 2, \dots, n \quad (1)
\end{aligned}$$

$y$  is a variable of interest. I use pre-transformed GDP and government spending as  $y$  variables following Barro and Redlick [2011] and Ramey and Zubairy [2014]. To be specific, the  $y$  variable for the GDP and the government spending equation have the following form:

$$\frac{Y_{t+h} - Y_{t-1}}{Y_{t-1}} \approx \ln Y_{t+h} - \ln Y_{t-1}, \quad \frac{G_{t+h} - G_{t-1}}{Y_{t-1}} \approx (\ln G_{t+h} - \ln G_{t-1}) \frac{G_{t-1}}{Y_{t-1}} \quad (2)$$

where  $Y$  is real per capita GDP, and  $G$  is real per capita government spending. The former is percentage deviations of GDP and is analogous to the form in the standard fiscal VAR. The latter is the transformation of percentage changes in government spending to dollar changes using  $G/Y$  at each period in time. With this form, changes in government spending and output are measured in the same unit, which is required to calculate multipliers. Furthermore, this particular form helps avoiding the bias in calculating multipliers. In the standard fiscal VAR, multipliers are usually calculated by multiplying estimated elasticity of GDP with respect to government spending by the sample mean of the government spending-to-GDP ratio. This method delivers reasonable multipliers if the ratio is stable. If the ratio fluctuates widely, however, multipliers calculated by this method could be biased, as shown in Ramey and Zubairy [2014]. Since this particular form converts percent changes into dollar changes using a value of the ratio at each point in time, rather than using a sample mean of the ratio, it is possible to avoid the bias caused by using the sample mean.<sup>10</sup> I also estimate the equation with log of debt, and interest

---

<sup>10</sup>The data that I use show that the whole sample mean of the ratio is 8, the minimum is 2 and the maximum is 24. The post WWII sample mean is 5, the minimum is 4 and the maximum is 7.

rate as  $y$  variables to investigate state-dependent behavior of government debt and interest rate.

$I$  is an indicator variable that has the value of one when the debt-to-GDP ratio exceeds a predetermined threshold, and is zero otherwise. The debt-to-GDP ratio is widely adopted in several literature such as Bohn [1998], Perotti [1999], and Ilzetzki et al. [2013] to measure the level of debt. For the baseline estimation, the threshold is set 45%.<sup>11</sup> If the threshold is set 0, the state-dependent model becomes the linear model in which responses are invariant across states. Figure 1 shows the time series plot of the debt-to-GDP ratio and the news variable. The high debt state consists of two periods: from the beginning of the 1940s to the mid-1960s and from the mid-1980s to the present day. Because of substantial military spending during WWII and the Korean War, the debt-to-GDP ratio exceeds the threshold and the news variable show sizeable variations during the first period. Additionally, the high level of debt in the second period is caused by significant tax reductions enacted by the Reagan and the Bush administrations, and the aftermath of the recent financial crisis and subsequent great recession.

$x$  is a vector of control variables. For the baseline model, I control the following variables: log of real per capita government spending, log of real per capita GDP, log of real per capita debt, and 10-year government bond interest rate. Including debt and interest rate would be helpful to capture debt-financing costs for the government. For robustness checks, moreover, I control the effects of tax policy using the series of tax rate constructed by Barro and Redlick [2011] and updated by Mertens [2013].<sup>12</sup> The lag for the controls  $j$  is set 4.<sup>13</sup>

---

<sup>11</sup>This number is not econometrically chosen but I tested several levels and find that the results with 45% and above are different from the results with levels below 45%. Ilzetzki et al. [2013] use a similar strategy to identify the break point.

<sup>12</sup>This series is available only in some sub-periods, thus I use that only for robustness checks.

<sup>13</sup>I estimate the model with different lags from 2 to 6. The results are robust to different lag

*shock* is a government spending shock identified by the defense news variable constructed by Ramey [2011a] and Owyang et al. [2013]. It is important to identify an exogenous and unanticipated government spending shock, so that I use the narrative approach using the defense new variable. The narrative approach using defense news is relatively free from the common criticism of the structural VAR method proposed by Blanchard and Perotti [2002] and Fatás and Mihov [2001]. I use the defense new variable scaled by one-period lagged nominal GDP to normalize the size of a shock.

One important issue in the narrative approach using the defense news is the relevance of the defense news variable. Ramey [2011a] points out that the estimation with the defence news variable could be interpreted as an instrumental variable regression. Consequently, it is important to know whether the defense news is a relevant instrument. Following Ramey [2011a], I conduct the F-test to test the relevance. Table 1 shows the results. In all cases except the high debt state, the F-statistics are well above the threshold level 10.<sup>14</sup> The marginal F-statistics for the high debt state is slightly below 10, but it is substantially higher than F-statistics of other instrumental variables in macroeconomic studies.<sup>15</sup> Overall, the results indicate that the news variable is relevant to accounting for changes in government spending. Moreover, observations for the high debt state is about 40% of entire observations, so that it is sufficient to capture state-dependent effects of government debt.

In addition, a cubic trend is included for the baseline estimation. Ramey and Zubairy [2014] emphasize that the importance of a higher order trend to capture slow moving demographics. According to Jordá [2005], moreover, the error term  $\varepsilon_{t+h}$  is a moving average of the forecast errors from  $t$  to  $t+h$ . To correct the effects of the serial correlated errors, I use the Newey-West standard error. In this

---

structure.

<sup>14</sup>The typical rule-of-thumb level is 10. See Staiger and Stock [1997].

<sup>15</sup>See Stock and Watson [2012]



specification, the collection of  $\{\beta_h^H\}_{h=0,\dots,n}$  could be interpreted as a response of  $y$  in a high debt state, while the collection of  $\{\beta_h^L\}_{h=0,\dots,n}$  means a response of  $y$  in a low debt state. For example,  $\beta_4^H$  represents a response of  $y$  to a shock after 4 quarter in a high debt state. Furthermore, the cumulative multiplier which I focus on in this paper is calculated by the following:

$$CM_k^i = \frac{\sum_{h=0}^k \Delta Y_h^i}{\sum_{h=0}^k \Delta G_h^i} = \frac{\sum_{h=0}^k \beta_{h,Y}^i}{\sum_{h=0}^k \beta_{h,G}^i}, \quad i = H, L \quad (3)$$

where  $\Delta$  means a response of a variable to a defense news shock, and subscripts  $Y$  and  $G$  indicate the GDP equation and the government spending equation, respectively.  $k$  is a horizon of interest.<sup>16</sup>

The local projection has several advantages comparing to nonlinear VAR models. The local projection is flexible to choose a form of variables. In this empirical analysis, the dependent variables and independent variables have different forms to avoid the bias in calculating multipliers. This is not easily implemented in VAR models. Second, nonlinear VAR models sometimes need an assumption on how a shock interacts with a state of the economy to calculate impulse responses. For example, Auerbach and Gorodnichenko [2012] assume that the economy stays in its current state for a long time regardless of a shock for their STVAR to simplify drawing impulse responses. In contrast to nonlinear VAR models, the local projection method utilizes the average behavior of the economy. Thus, it does not depend on such a specific assumption.<sup>17</sup>

---

<sup>16</sup>Mountford and Uhlig [2009] and Fisher and Peters [2010] argue that the multiplier relevant for policy makers is the cumulative multiplier.

<sup>17</sup>Auerbach and Gorodnichenko [2011] and Ramey and Zubairy [2014] also provide a nice summary on nonlinear VAR models and the local projection method.

### II.3 Baseline Results

This section provides baseline estimation results. Figure 2 shows the estimated impulse response of GDP, government spending, interest rate, and government debt to an increase in the defense news by 1% of GDP in the liner model (threshold is set 0%) as a benchmark. The responses of government spending and GDP are positive and reach the maximum at 12 quarters after a shock. The response of interest rate is negative, which is consistent with several studies such as Perotti [2004] and Ramey [2011a]. After a shock, government debt begins increasing and peaks around 17 quarters.

Figure 3 shows the responses of the variables in the state-dependent model. In a low debt state, government spending, GDP, and debt have positive and robust responses as in the linear model. The responses of government spending and GDP in a low debt state peak around 14 quarters, and debt has a peak around 17 quarters. In a high debt state, however, the responses become totally different. Government spending has a weak response and turns negative after 15 quarters, and debt has only a small and statistically insignificant response. The response of government spending could be interpreted as the government tries to stabilize debt levels through limiting debt-financed spending and future reductions in spending below the trend in a high debt state, whereas the government cares less about debt levels in a low debt state.

In contrast to most theoretical works in which government spending is treated as a purely exogenous process,<sup>18</sup> existing empirical literature support that government spending is systematically reduced by an increase in government debt.<sup>19</sup> How could

---

<sup>18</sup>For example, Galí et al. [2007a] and Woodford [2011] assume that the government spending rule follows the pure autoregressive process, which implies that budget deficits are corrected only by tax increases.

<sup>19</sup>For example, Galí and Perotti [2003], Reicher [2012] (single equation approaches), Chung and Leeper [2007], Corsetti et al. [2012a] (VAR models), Leeper et al. [2010], and Zubairy [2014] (estimated DSGE models) provide such evidence. In particular, Corsetti et al. [2012a] provide

we interpret that systematic reductions in spending caused by government debt? One way to interpret is that the government tries to stabilize government debt levels through not only tax increases but also spending cuts. Bohn [1991] and Auerbach [2000] show that historically US budget deficits have been corrected by combination of both spending cuts and tax increases. Furthermore, recent fiscal consolidation through spending cuts in many advanced countries is also matched to this interpretation.<sup>20</sup>

However, those systematic reductions in spending to stabilize debt levels possibly take place in a nonlinear manner. Several empirical studies, typically on the debt sustainability, suggest that behavior of fiscal instruments significantly differs by the level of debt (or the size of budget deficits). For example, Bohn [1998] estimates how US primary budget surpluses respond to debt using a single equation approach and finds that the marginal response of budget surpluses to debt is positive and statistically significant when the debt-to-GDP ratio is above the sample average, whereas that is negative and statistically insignificant when the debt-to-GDP ratio is below the sample average. Afonso and Sousa [2012] and Checherita-Westphal and Rother [2012] also show similar results.<sup>21</sup> Those results would imply that the

---

evidence for the US suggesting that an exogenous increase in government spending leads a rise in government debt, and that rise in debt causes future reductions in spending below trend, called spending reversals. Those spending reversals are observed in a high debt state in this paper.

<sup>20</sup>For instance, the US Congressional budget office announces that federal discretionary spending will be reduced from 7.2% of GDP in 2013 to 5.2% in 2024 to reduce budget deficits and to stabilize government debt levels. Furthermore, some researchers claim that spending cuts are more efficient to reduce debt levels and enhancing future growth than tax increases. See Alesina and Perotti [1995] and Alesina and Ardagna [2009].

<sup>21</sup>Afonso and Sousa [2012] show that government spending responds to debt more negatively when the debt-to-GDP ratio exceeds some threshold in the US using estimating a VAR model incorporated the debt-feedback equation as in Favero and Giavazzi [2007]. Checherita-Westphal and Rother [2012] also show that the impact of debt on government investment is positive when the debt-to-GDP ratio is below some threshold, whereas that turns negative when the debt-to-GDP ratio exceeds that threshold using data on euro countries. Moreover, Sarno [2001], Arestis et al. [2004], Cipollini et al. [2009], and Piergallini and Postigliola [2013] also provide similar evidence. In particular, Arestis et al. [2004], and Cipollini et al. [2009] show that the government only intervenes to reduce budget deficits mainly through spending cuts when the deficits exceed a certain threshold

systematic reductions in spending to stabilize debt levels take place more strongly or abruptly when the debt-to-GDP ratio exceeds some threshold.

The responses of government spending in this paper are in line with those nonlinear behavior of stabilizing debt levels. The weak and negative response of government spending to an exogenous spending shock in a high debt state may imply that the government tries to avoid increasing in debt-financed spending and reduce spending below the trend to stabilize debt levels in a high debt state. As a result, debt has a small and insignificant response in a high debt state. In contrast to the response of spending in a high debt state, the response of spending in a low debt state is strong and robust, which would imply that the government less cares about increasing in spending financed by debt in a low debt state. Consequently, debt has a strong and robust response in a low debt state. Thus it would be reasonable to interpret the results as the government tends to put large efforts to stabilize debt levels through limiting debt-financed spending and subsequent spending reductions in response to an exogenous change in government spending in a high debt state.

The response of GDP in a high debt state is also weak and turns negative after 13 quarters. In contrast to the response of other variables, the responses of interest rate do not statistically differ across states. Thus I do not find strong evidence to support interest rate nonlinearity due to default risks in the theoretical literature such as Bi [2012] and Corsetti et al. [2013]. It may be caused by low default risks to US government debt.

Figure 4 shows the estimated cumulative multipliers. In the linear model, the estimated multiplier on impact is 0.88, which implies that an increase in government spending by \$1 induces an increase in GDP by \$0.88. The multiplier decreases soon after, and the 1-year cumulative multiplier becomes 0.67. However, it starts to

---

in the US.

increase after 1 year, and the 5-year cumulative multiplier becomes 0.86. All those numbers are consistent with previous VAR evidence.<sup>22</sup> Additionally, the estimated multipliers are statistically significant at all horizons. The estimated multipliers in a low debt state show the similar pattern as in the linear model. On impact, the multiplier is 0.73, which is similar to that in the linear model. The estimated multiplier decreases soon after, and the 1-year cumulative multiplier becomes 0.58. However, it begins to increase after 1 year, which is the same as in the linear model, and the 5-year cumulative multiplier becomes 0.85. Furthermore, the estimated multipliers in a low debt state are statistically significant at all horizons as in the linear model. However, the estimated multipliers in a high debt state show the totally different pattern compared with that observed in the linear model and a low debt state.<sup>23</sup> The estimated multiplier on impact in a high debt state is 2.16 which is much larger than that in a low debt state, though it is not statistically significant. However, it is not easy to interpret the statistically insignificant impact multiplier in a high debt state because the contemporaneous response of GDP in a high debt state is positive and statistically significant. It seems that the wide confidence band of the impact multiplier in a high debt state is caused by the large uncertainty of contemporaneous response of government spending. The multiplier drops sharply soon after, and the 1-year cumulative multiplier becomes 1, which is still larger than that in a low debt state and statistically significant. In contrast to the linear model and a low debt state in which the multiplier begins to increase after 1 year, the multipliers in a high debt state continue to decrease after 1 year, and the 5-year cumulative multiplier becomes 0.43. It implies that the linear model cannot capture the continuously decreasing cumulative multipliers in a high debt state. Moreover, the results indicate that the

---

<sup>22</sup>Hall [2009] suggests that the range of multipliers in VAR literature is between 0.7 and 1.

<sup>23</sup>Since the confidence band of the multipliers on impact in a high debt state is wide, I report the figure with trimmed  $y$  axis.

short-run multipliers in a high debt state are not necessarily smaller than those in a low debt state, which is sharply contrary to the conventional wisdom.<sup>24</sup> In contrast to the finding for short-run multipliers, the long-run multipliers in a high debt state are smaller than those in a low debt state. For example, the difference of the 5-year cumulative multiplier in a high debt state and a low debt state is -0.6, and that difference is statistically significant at the 10% level.

In summary, the responses of government spending, GDP, and debt are significantly differ by the level of debt. Those in a low debt state are positive and robust. However, the responses of government spending and GDP in a high debt state are weak and turn negative. The response of debt in a high debt state is also weaker than that in a low debt state. The linear model does not capture the weak and statistically insignificant responses of government spending, GDP and debt in a high debt state. In contrast to the other variables, the long-term interest rate has the similar response across states, which may be caused by low default risks to US government bond. Furthermore, the short-run multipliers in a high debt state are larger than those in a low debt state, which is sharply contrary to the conventional wisdom.

## II.4 Robustness

In this section, I report the various robustness check results. In section II.4.1, the results with different time trends, thresholds, and other specification are provided. Section II.4.2 provides the results with the tax rate constructed by Barro and Redlick [2011] and updated by Mertens [2013] are shown, which helps understanding the role of taxes.

---

<sup>24</sup>I discuss on this difference in section .

#### II.4.1 Robustness: Different Time Trends, Thresholds, and Other Specifications

Table 2 shows the results with different time trend and threshold assumptions. The result with 60% threshold, the same threshold in Ilzetzki et al. [2013], shows the same implications as in the baseline case. The estimated multipliers in a low debt state show the same pattern as shown in the baseline model: the multiplier is small in short-run, but it grows larger in long-run. However, the multipliers in a high debt state are large in short-run, but those decrease soon after. Moreover, the estimated short-run multipliers are larger than those in a low debt state. However, the result with the 35% threshold shows the different results. In this case, both of the short-run and the long run multipliers in a high debt state are smaller than those in a low debt state. With a low threshold, two states may not be clearly separated, which possibly causes different implications.

Furthermore, time series models are sometimes sensitive to a trend assumption, thus I report the estimation results with different time trends. Note that the sample periods in this paper are much longer than those in a standard time series analysis, thus a higher order trend such as a quartic trend could be important. The estimated multipliers with a quartic trends in a high debt state are slightly lower than those in the baseline case. However, the short-run multipliers in a high debt state are still larger than those in a low debt state. The result with a quadratic trend also gives the same implication.

Next, I estimate the model with the first difference of the controls instead of the level of the controls. This specification could mitigate measurement errors of the variables. The result also confirms that the short-run multipliers in a high debt state are larger than those in a low debt state. In this case, the 5-year cumulative multipliers in a high debt state is not much smaller than that in a low debt state.

Following Barro and Redlick [2011], moreover, I control the lagged unemployment rate and the credit spreads. They emphasize the importance of unemployment rate to control the amount of slack in estimating spending multipliers. Moreover, since the sample period includes the Great Depression and some periods of the financial crisis, credit conditions could be important to determine output dynamics as argued in Barro and Redlick [2011]. To control credit conditions, I use the spreads between long-maturity Baa-rated corporate bond and 10-year government bond following Barro and Redlick [2011]. This credit spreads may capture credit market conditions.<sup>25</sup> The result also confirms the findings in the baseline case.

It is reasonable to be concerned about the effects of the war time rationing during WWII. As shown in Perotti [2011], the war time rationing could be source to alter the estimated spending multipliers. Thus, I report the results with the data excluding WWII (1939.Q3 to 1946.Q4).<sup>26</sup> The result show that the multipliers in a low debt state are slightly larger than those in the baseline case. However, the short-run multipliers in a high debt state are still larger than those in a low debt state.

To compare with the previous studies which mainly focus on the post WWII period, I also report the results with the post WWII data. The result show that the multipliers in a low debt state are larger than those in a low debt state. However, the 1-year cumulative multiplier in a high debt state is still larger than those in a low debt state. The result seems to confirm that the findings in the baseline case.<sup>27</sup>

---

<sup>25</sup>I control 4 lags of the variables. The unemployment series is taken from the data constructed by Owyang et al. [2013]'s. The series of Baa corporate bond yield is taken from the website of the Federal Reserve Bank of St. Louis. The Baa corporate bond yield series is available after 1919. Thus the sample periods for the regression with the credit spreads starts 1919.Q1.

<sup>26</sup>Ramey and Shapiro [1998] point out that the effects of the rationing, the price control and, the draft during the Korean War and the Vietnam War are small.

<sup>27</sup>Due to the observation loss, typically for a low debt state, I choose the higher threshold value for the post-WWII case. Furthermore, I use a quadratic trend which is more conventional in the estimation with post-WWII period instead of a cubic trend. In addition, it should be careful to interpret this result since the defense news variable has low explanatory power for post-WWII government spending, especially in a low debt state. The marginal F-statistic for a high debt state



Overall, all robustness checks confirm the findings in the baseline model: the multipliers in a high debt state are not necessarily smaller than those in a low debt state, at least, in short-run.<sup>28</sup>

#### II.4.2 Robustness: Control Tax Policy

Tax policy is another important factor to determine effects of government spending on output. The conventional wisdom argues that distortionary taxation is a key to reduce stimulus effects of government spending in a high debt state. Barro and Redlick [2011] also point out that an increase in tax rate induced by an increase in government spending possibly affects output negatively. Therefore a channel based on tax policy could be another source to alter multipliers. In order to control tax policy, I include federal individual income tax rate (FITR) constructed by Barro and Redlick [2011] and updated by Mertens [2013] in the estimation equation. This tax rate is interpreted as distortionary labor income tax rate since Barro and Redlick [2011] focus on estimating the tax rate closely related to labor income. Note that the original tax rate series constructed by Barro and Redlick [2011] consists of three components: FITR, the social security tax rate, and the state tax rate, and I use FITR which is the main variation source of that series instead of the all components due to data availability. The original tax rate constructed by Barro and Redlick [2011] is only available from 1913 to 2006. Fortunately, Mertens [2013] updates FITR from 2006 to 2010, thus it is possible to minimize the observation loss using FITR.<sup>29</sup> The sample periods are 1913.Q1 to 2010.Q4 due to data availability. The

---

(threshold is set 60%) is 11.74, but that for a low debt state is only 2.00.

<sup>28</sup>In addition, I estimate the model with other specifications to check robustness. For example, I estimate the model with the 3 month treasury bill rate to control the effects of monetary policy. To control the effects of the zero-lower bound, moreover, I estimate the model with the data excluding the periods in which the 3 month treasury bill rate is less than 0.25%. The results are not changed.

<sup>29</sup>The estimation results with the original series constructed by Barro and Redlick [2011] show the same implications. Moreover, this tax series is only available at annual frequency. Therefore, I

threshold is set 45% which is the same in the baseline model. Moreover, I control all the variables in the baseline equation and 4 lags of the tax rate.

Figure 5 shows the response of government spending, GDP, interest rate, debt, and the tax rate to a rise in the defense news by 1% of GDP in the linear model. The responses of government spending, GDP, interest rate, and government debt in the linear model are similar to those in the baseline estimation. Additionally, the tax rate starts increasing and peaks around 12 quarters after a shock.

Figure 6 shows the state-dependent responses of the variables. The responses of government spending, GDP, and government debt are similar to the baseline case. Those are weak and turn negative after some point in a high debt state, whereas those are positive and robust in a low debt state. The responses of interest rate are not statistically different across state, which is also similar to the response in the baseline model. Furthermore, the responses of tax rate differ by the level of debt. The response of the tax rate in a low debt state is positive and robust, which is similar to the linear model. In contrast to the response of the tax rate in the linear model and a low debt state, the response of the tax rate in a high debt state is weak and turns negative after 14 quarters. Based on the response of the tax rate, I compute the ratio of the cumulative tax receipts to the cumulative government spending.<sup>30</sup> Figure 7 show the results. The result shows that the tax fraction of government spending in a linear model and a low debt state is around 40% after 1 year. However, the tax fraction of government spending in a high debt state is somewhat different. At 1

---

use repeated samples to estimate the equation following Ramey [2011a]. For example, the tax rates in 2000.Q1, Q2, Q3, Q4 have the same value which is the tax rate in 2000.

<sup>30</sup>To compute the ratio, I use the following formula:  $G = deficit + \tau Y$ , where  $G$  is real government spending,  $\tau$  is the tax rate, and  $Y$  is real GDP. Then changes in government spending normalized by output is  $\frac{\Delta G}{Y} = \frac{\Delta Deficit}{Y} + \Delta \tau + \tau \frac{\Delta Y}{Y}$ . With this particular form, I can compute the ratio of tax receipts to government spending. I assume that the steady-state tax rate,  $\tau$ , in a high debt state is 0.22%, which is the sample average of the tax rate in a high debt state and that in a low debt state is 0.13%. For the linear model,  $\tau$  is assumed 0.18%, which is the sample average.

year, more than 70% of cumulative government spending is financed by debt. This result seems that the government prefers tax-financed spending in a high debt state. At 5 year, however, less than 30% of cumulative government spending is financed by debt. This result does not seem to support a large increases in distortionary taxes in a high debt state. Overall, I do not find strong evidence to support that the government prefers tax-financed spending in a high debt state. The result provides mixed evidence at best.

Figure 8 shows the estimated spending multipliers. Overall, the estimated multipliers are similar to those in the baseline model, though the confidence bands become wider.<sup>31</sup> The multiplier on impact in the linear model is 1.24, which is slightly larger than that in the baseline model. The multiplier decreases until 1 year, but it starts to increase after 1 year. The estimated multipliers in a low debt state also show the same pattern as in the baseline case. The estimated multiplier on impact in a low debt state is 0.98. It decrease soon after, and the 1-year cumulative multiplier becomes 0.61. However, it start to increase after 1 year, and the 5-year cumulative multiplier becomes 1.00. Moreover, the pattern of estimated multiplier in a high debt state is similar to that in the baseline model.<sup>32</sup> The impact multiplier is 4.46, which is larger than that in a low debt state, but it starts to decrease sharply until 1 year. The 1-year cumulative multiplier in a high debt state is 1.21 and statistically significant. After 1 year, the multipliers keep decreasing slowly, which is contrary to those in the linear model and a low debt state in which the cumulative multiplier start to increase after 1 year. The 5-year cumulative multiplier in a high debt state

---

<sup>31</sup>The wide confidence band may not be caused solely by adding tax rate as a control variable. I re-estimate the equation with the same sample periods (1913 to 2010), but without tax rate. The confidence band in this case is still wider than that in the baseline case. Thus parts of the wide confidence band seem to be caused by the observation loss.

<sup>32</sup>Since the confidence band for the multipliers on impact in a high debt state is wide, I report the figure with trimmed  $y$  axis.

is 0.30, which is significantly lower than that in a low debt state. Furthermore, the short-run multipliers in a high debt state are larger than those in a low debt state as in the baseline model.

In general, the model with the tax rate also gives the same implications as in the baseline case. The response of government spending, GDP, and debt in a high debt state are weak, but those in a low debt state and the linear model are strong and robust. The responses of interest rate are not statistically different across states. In addition, I do not find strong evidence to support a large increases in distortionary taxes in a high debt state. Furthermore, the estimate multipliers with the tax rate show the same implications as in the baseline model: the short-run multipliers in a high debt state are larger those in a low debt state.

## II.5 The Large Short-run Multiplier in a High Debt State: A New Keynesian Lens

The empirical results in this paper reveal that the short-run multipliers in a high debt state are larger than those in a low debt state, which is contrary to the conventional prediction. What drives those results? One possible candidate is the interaction between spending reversals and monetary policy suggested by Corsetti et al. [2012a].

Corsetti et al. [2012a] demonstrate that short-run multipliers in the case with spending reversals could be larger than those in the case without spending reversals using a calibrated New Keynesian model. Their model reveals that future spending cuts in response to a rise in debt could reduce future inflation and, via the monetary authority's reaction function, future real interest rate. Since households anticipate real interest rate below the trend in the future, they increase their current consumption through the intertemporal substitution mechanism, and that magnifies short-run

stimulus effects of government spending.<sup>33</sup> In the empirical analysis, spending reversals are observed only in a high debt state. Thus it is possible to conjecture that those spending reversals magnify short-run stimulus effects of spending in a high debt state.

Although Corsetti et al. [2012a] provide a potential theoretical framework to understand the large short-run multipliers in a high debt state, they do not explicitly consider the state-dependent effects of debt on government spending such as a state-dependent spending rule. Here, I construct a new Keynesian model incorporated a state-dependent government spending rule to evaluate the effects of debt levels on government spending. The model is based on the parsimonious model in Corsetti et al. [2012a] except the government spending rule and the defense news process. The government spending rule is assumed state-dependent based on the empirical finding. Specifically, spending reversals take place more strongly when the debt-to-GDP ratio exceeds some threshold.

### II.5.1 The Model

The structure of the model is simple and close to the standard New Keynesian model. The economy consists of three types of agents: households, firms, and the government.

---

<sup>33</sup>Forni and Pisani [2010], and Cimadomo et al. [2011] provide some empirical evidence to support this view. Forni and Pisani [2010] show that the short-run multipliers become larger in the presence of spending reversals using a estimated DSGE model. Cimadomo et al. [2011] also show that an exogenous increasing in government spending with anticipated future spending cuts generates larger expansionary effects on the economy in short-run comparing to an increase in spending without anticipated future spending cuts using a VAR model and the US real-time data.

### II.5.1.1 Households

A representative household maximizes her life-time utility subject to the budget constraint. The life-time utility is given by

$$E_t \sum_{i=0}^{\infty} \beta^i \left( \frac{C_{t+i}^{1-\sigma}}{1-\sigma} - \frac{H_{t+i}^{1+\phi}}{1+\phi} \right) \quad (4)$$

where  $C_t$  is consumption in time  $t$ , and  $H_t$  is labor supply.  $0 < \beta < 1$  is the discount factor,  $\sigma > 0$  is the relative risk-aversion coefficient, and  $\phi > 0$  is the inverse Frisch elasticity of labor supply. The period-by-period budget constraint is as follows:

$$P_t C_t + A_t = W_t H_t + R_{t-1} A_{t-1} + \Gamma_t - P_t T_t \quad (5)$$

$P_t$  is the price index of the consumption good,  $A_t$  are the one-period nominal domestic government bonds, and  $R_t$  is the corresponding gross nominal interest rate. Moreover,  $W_t$  is the nominal wage,  $\Gamma_t$  is the profits from intermediate good firms, and  $T_t$  is the real lump-sum transfers. The representative household chooses labor supply, consumption, and quantity of government bonds to maximize her life time utility. The optimality condition for labor supply is given by

$$\frac{H_t^\phi}{C_t^{-\sigma}} = \frac{W_t}{P_t} \quad (6)$$

Also, the optimality condition for the intertemporal choice is given by

$$C_t^{-\sigma} = \beta E_t \left[ C_{t+1}^{-\sigma} \frac{P_t}{P_{t+1}} R_t \right] \quad (7)$$

### II.5.1.2 Firms

There are two kinds of firms: the final good firm and the intermediate good firm. The final good  $Y$  is a composite of intermediate goods which are produced by a continuum of monopolistic competitive intermediate good firms. The final good firms operate in perfect competitive markets and try to minimize their expenditures subject to the following aggregation technology.

$$Y_t = \left[ \int_0^1 Y_t(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}} \quad (8)$$

where  $Y_t(j)$  is a intermediate good produced by  $j$ th intermediate good firm.  $\epsilon$  measures the price elasticity of intermediate goods. The expenditure minimization implies that the associated price indexes of  $Y_t$  is

$$P_t = \left( \int_0^1 P_t(j)^{1-\epsilon} dj \right)^{\frac{1}{1-\epsilon}} \quad (9)$$

Also, there is a continuum of intermediate good firms  $[0, 1]$  which could access the following production technology

$$Y_t(j) = H_t(j)^{1-\alpha} \quad (10)$$

where  $Y_t(j)$  is the output of  $j$ th firm,  $H_t(j)$  is the labor demand of  $j$ th firm, and  $0 \leq \alpha < 1$ . Firms are operated in a imperfect competitive market, and each firm sets its own price with Calvo fashion. Thus, the profit maximizing problem of  $j$ th firm is as follows:

$$\max_{P_t(j)} E_t \sum_{i=0}^{\infty} \xi^i E_t \Lambda_{t,t+i} Y_{t+i}(j) [P_t(j) - P_{t+i} MC_{t+i}(j)] \quad (11)$$

where  $1 - \xi$  is the probability of price adjusting,  $\Lambda$  is the stochastic discount factor of the representative household, and  $MC$  is the real marginal cost. The optimality condition for each intermediate good firm is given by

$$E_t \sum_{i=0}^{\infty} \xi^i \Lambda_{t,t+i} Y_{t+i}(j) \left[ P_t(j) - \frac{\epsilon}{\epsilon - 1} P_{t+i} MC_{t+i}(j) \right] = 0 \quad (12)$$

The real marginal cost is the same across firms and is given by

$$MC_t = \frac{W_t}{P_t} \frac{1}{(1 - \alpha) H_t^{-\alpha}} \quad (13)$$

### II.5.1.3 The Government

The monetary authority adjusts nominal interest rate  $R_t$  with the following simple Taylor-rule.

$$R_t = R \Pi_t^{\phi_\pi} \quad (14)$$

where  $R$  is the steady state gross nominal interest rate, and  $\Pi_t = P_t/P_{t-1}$  is the inflation at time  $t$ . The period-by-period budget constraint of the government is given by

$$D_t = R_{t-1} D_{t-1} + P_t G_t - P_t T_t \quad (15)$$

where  $D_t$  is nominal government debt, and  $G_t$  is real government spending.

The defense news,  $news$ , is assumed to be

$$news_t = news + \zeta_t \quad (16)$$

$news$  indicates the steady-state level of the defense news. Without loss of generality, the steady state value of  $news$  is assumed zero. The government spending rule is



assumed to be the following:

$$G_t = (1 - \sum_{i=1}^j \psi_{gg}^i G) + \sum_{i=1}^j \psi_{gg}^i G_{t-i} + I_{t-1} \left( \psi_{gnews}^H (news_t - news) - \psi_{gd}^H (d_{t-1} - d) \right) + (1 - I_{t-1}) \left( \psi_{gnews}^L (news_t - news) - \psi_{gd}^L (d_{t-1} - d) \right) + \delta_t \quad (17)$$

where  $G$  is the steady state government spending,  $d_t$  is the real government debt at time  $t$ ,  $d$  is the steady state real government debt, and  $Y$  is the steady state output. Thus  $d_t/Y$  could be interpreted as the debt-to-GDP ratio at time  $t$ .  $\psi_{gg}^i$  captures the persistence of government spending.  $I$  is an indicator function, which is defined by

$$I_t = \begin{cases} 1 & \text{if } d_t/Y > \text{threshold} \\ 0 & \text{Otherwise} \end{cases} \quad (18)$$

Thus,  $I$  has the value one when the debt-to-GDP ratio exceeds a threshold.  $\psi_{gnews}^H$  and  $\psi_{gnews}^L$  capture the contemporaneous response of government spending to the defense news in a high debt state and in a low debt state, respectively. I assume that  $\psi_{gnews}^L \geq \psi_{gnews}^H > 0$  to capture the strong contemporaneous response of spending to a shock in a low debt state. Moreover,  $\psi_{gd}^H$  and  $\psi_{gd}^L$  captures the response of spending to debt in a high debt state and in a low debt state, respectively. Based on the empirical finding, I assume that  $\psi_{gnews}^H > \psi_{gnews}^L \geq 0$ .  $\delta$  is an exogenous part of government spending. Moreover, the adjustment process of lump-sum tax is assumed to be

$$T_t = T + \psi_{td} (d_{t-1} - d) \quad (19)$$

where  $T$  is the steady state lump-sum transfers.  $\psi_{td} > 0$  captures the responsiveness of lump-sum tax to government debt, which is similar to Corsetti et al. [2012a].

#### II.5.1.4 Equilibrium

The labor market clearing condition is given by

$$H_t = \int_0^1 H_t(j) dj \quad (20)$$

In the equilibrium, the supply and the demand of each intermediate good firm should be matched and the following aggregate condition is satisfied.

$$Y_t = C_t + G_t \quad (21)$$

Finally, the asset market clearing condition is as follows.

$$A_t = D_t \quad (22)$$

#### II.5.2 Calibration

This section provides the calibration for the numerical study. Table 3 summarizes calibration for the simulation study. The discount factor  $\beta$ , the risk aversion coefficient  $\sigma$ , and the inverse Frisch elasticity  $\phi$  are standard and similar to those in the real business cycle literature. The price stickiness parameter  $\xi$  is set to be 0.8 to match with the five quarters average price duration. Also, I assume that the price elasticity  $\epsilon$  is equal to 11 to match 10% of the steady state mark up. The labor share  $1 - \alpha$  is equal to 0.7, which is similar to Corsetti et al. [2012a].

For the policy block, I use the following assumptions. To capture the persistent and hump-shaped response of government spending to a defense news shock, I assume that the government spending rule depends on 3 lags, which is the same as in Ramey [2011a]. The persistence of government spending  $\psi_{gg}^1, \psi_{gg}^2, \psi_{gg}^3$  are set 1.32,

−0.18, and −0.2, respectively, based on my estimation. To do this calibration, I estimate AR(3) model with the full sample government spending data. The numbers are also close to those in Ramey [2011a]. To capture the state-dependent responsiveness of spending to debt, I assume that the responsiveness of spending to debt in a high debt state  $\psi_{gd}^H$  is 0.02 and that in a low debt state,  $\psi_{gd}^L$  is 0. Therefore, government spending responds to debt only in a high debt state in the numerical study. Furthermore, I assumed that the contemporaneous response of government spending to the defense news in a high debt state is 0.01 and that in a low debt state is 0.08 based on the baseline estimation result. The contemporaneous response of government spending to an increase in the defense news by 1% of GDP in a high debt state is 0.01%, and that in a low debt state is 0.08% in the baseline estimation. Additionally, the responsiveness of the lump-sum tax to debt  $\psi_{td}$  is assumed to be 0.02, which is the same as in Corsetti et al. [2012a]. The coefficient for the Taylor rule  $\phi_\pi$  is set to be 1.5, which is fairly standard.

In addition, the steady state share of government spending to output is assumed 20% to match with the post WWII US time series data. The threshold value of the debt-to-GDP ratio is set 45%, which is the same as in the baseline estimation. I will discuss the steady state debt-to-GDP ratio in the next section.

### II.5.3 The Impulse Response Analysis

It is not easy to solve the model using the usual log-linear approximation and the fully stochastic environment because the government spending rule is assumed state-dependent. To deal with this nonlinearity, I simulate the calibrated model under the perfect foresight assumption following Corsetti et al. [2013], and Michaillat [2014].<sup>34</sup>

---

<sup>34</sup>With this assumption, we can deal with nonlinear equations directly. Heer and Maussner [2009] provide detailed discussion.

Specifically, I assume that the economy is in the steady state at time 0. At time 1, a defense new shock hits the economy and no shock occurs after that. In the empirical analysis, furthermore, each state is defined by the initial level of debt. To capture this situation, I assume that the steady state debt-to-GDP ratio in a low debt state is assumed 23%, which is the sample average of the debt-to-GDP ratio in a low debt state. Similarly, the steady state debt-to-GDP ratio in a high debt state is assumed 68%.<sup>35</sup> Figure 9 shows selected impulse responses to an increase in the defense news by 1% of output in two states. Note that the economy always stays in its initial state in this simulation because the debt-to-GDP ratio never exceeds the threshold when the economy starts in a low debt state and the debt-to-GDP never falls below the threshold when the economy starts in a high debt state.<sup>36</sup>

The responses of government spending, output, and debt are qualitatively similar to the empirical results. The response of government spending in a high debt economy is weak and turns negative at some point, whereas that in a low debt state is strong and positive. Debt has a weak response in a high debt state, but that has a strong response in a low debt state. Furthermore, the response of output in a high state turns negative at some point, which is also matched to the empirical results, at least, qualitatively.

The notable difference between two states is the response of consumption. In a low debt state, the response of consumption is negative, but that in a high debt state is positive. In a low debt state, government spending always has a positive response since it never responds to debt. Since firms increase their price in response to an increase in aggregate demand, the response of inflation is positive and, via the

---

<sup>35</sup>This assumption implies that the economy reverts to the initial state after the effects of a temporary increase in government spending disappears.

<sup>36</sup>This situation is consistent with the empirical analysis since figure 1 shows that the average duration of each state is not short and transitions between two states rarely happen.

monetary policy reaction function, real interest rate increases in a low debt economy. Therefore households reduce their consumption in response to a rise in real interest rate, which limits short-run stimulus effects. The 1-year cumulative multiplier in a low debt economy is around 0.5. Since government spending systematically responds to debt in a high debt state, however, the response of spending turns negative at some point. That negative response reduces aggregate demand and therefore firms decrease their price in response to a decrease in aggregate demand. Consequently, the response of inflation turns negative, and real interest rate decreases. Thus households increase their current consumption through the intertemporal substitution mechanism and that magnifies short-run stimulus effects. As a result, the 1-year cumulative multiplier in a high debt economy is 1.2, which is larger than 1 as well as that in a low debt economy. This simple model suggests that a state-dependent government spending rule in which spending reversals take place more strongly or abruptly when the debt-to-GDP ratio exceeds some threshold may be useful to understand the large short-run multipliers in a high debt state.<sup>37</sup>

It is worth noting that the large short-run multipliers in a high debt economy is mainly due to the responsiveness of spending to debt, not due to the high level of debt itself or the small contemporaneous response of spending to a defense news shock. The large short-run multipliers in a high debt economy are caused by spending cuts below trend due to the negative feedback from debt to spending. However, the high debt-to-output ratio itself and the small contemporaneous response of spending to a shock cannot lead those spending cuts.<sup>38</sup>

---

<sup>37</sup>Note that the responses of interest rate in the empirical model are not different across states. However, I use 10-year government bond interest rate to test interest rate nonlinearity due to sovereign default risks in the empirical analysis, which is not closely related to monetary policy.

<sup>38</sup>The high level of steady state debt means that debt service costs are large relative to the case with the low level of debt. The government should issue more debt to pay larger debt service costs in a high debt economy, so that the response of debt to a shock in a high debt state is stronger than that in a low debt economy. However, the quantitative effects of debt service costs are small.

Although this exercise shows how the state-dependent government spending rule alters spending multipliers, we cannot observe the transition between two states. To see the transition behavior, I conduct another numerical exercise. In the exercise, the steady state debt-to-GDP ratio is assumed 44%, which implies that the economy starts in a low debt state. Under the assumption, the debt-to-GDP ratio exceeds the threshold around 10 quarters after an increase in the defense news by 1% of output. Figure 10 shows the result. I also report the case with the linear spending rule in which government spending does not respond to debt to see the nonlinear effect clearly. Solid lines indicate that the responses of the variables with the linear government spending rule, and dashed lines indicate that the response of the variables with the nonlinear government spending rule.

In the nonlinear case, government spending responds to debt around 10 quarter so that future spending cuts take place. Since households anticipate future spending cuts and lower future interest rate, they increase current consumption. However, since government spending never responds to debt in the linear case, an increase in government spending crowds out households consumption through the interest rate channel. As a consequence, the short-run response of output in the nonlinear cases is much larger than that in the linear case. The estimated 1-year cumulative multipliers in the nonlinear case is 0.9, and that in the linear case is 0.5.

## II.6 Concluding Remarks

This chapter examines the state-dependent effects of government debt on government spending multipliers using state-dependent impulse responses drawn by the

---

Furthermore, the small contemporaneous response of spending to a shock in a high debt economy is not related to the positive response of consumption. In this simulation,  $\psi_{news}$  works only as a scale factor. Furthermore, the wealth effective is another potential candidate to explain the large short-run multipliers in a high debt state since tax burden is reduced in the presence of future spending cuts.

two-states local projection method, US historical data, and a government spending shock identified by the defense news variable constructed by Ramey [2012], and updated by Owyang et al. [2013]. For the estimation, a new quarterly historical US government debt data from 1890.Q1 to 2010.Q4 is constructed. The empirical results reveal that the spending multipliers in a high debt state are larger than those in a low debt state, at least, in short-run, which is contrary to the conventional prediction. To provide a possible channel to understand the result, I construct a simple New Keynesian model. The simple model suggests that spending reversals and the interaction between those spending reversals and monetary policy in a high debt state could be a potential channel to understand the large short-run multipliers in a high debt state. The empirical and theoretical results may imply that the short-run stimulus effects of government spending depends not only on current spending but also on future spending plans. Thus, it is important to manage households' expectation of future spending plans for the performance of a fiscal stimulus package as well as fiscal consolidation.

This research could be extended in several directions. First, it is important to construct other historical macroeconomic data and to investigate transmission channels of government spending. Particularly, the simple theory suggests that the responses of consumption and real interest rate may significantly differ by the level of debt. Thus it is worth constructing historical household consumption and real interest data and investigating how responses of those variables to a spending shock depend on the level of debt. Second, a rigorous theoretical model to explain the empirical results is worth developing. Although the theoretical model that I construct provides a potential channel to understand the empirical results, the model omits several important dimensions such as investment dynamics, external sectors, and other frictions. Moreover, it could be important to introduce nominal interest rate

zero lower bound and to study the interaction between nonlinear fiscal policy and monetary policy at the zero lower bound. Furthermore, it is worth conducting a simulation under the fully stochastic environment to study how the precautionary motive affects the performance of government spending.



## CHAPTER III

### STRUCTURAL CHANGES? FISCAL POLICY AND TWIN DEFICITS IN A TIME VARYING STRUCTURAL VAR

#### III.1 Introduction

Do government budget deficits always lead external deficits? In the aftermath of the financial crisis and the great recession, many developed and developing countries suffer from huge budget deficits and external deficits, and a number of countries face the challenge to reduce budget deficits and external deficits together.<sup>39</sup> In fact, the challenge is closely related to the twin deficit hypothesis: budget deficits cause external deficits. Despite the hypothesis has important policy implications for recent economic situations, no clear consensus has been reached regarding the hypothesis. For example, Monacelli et al. [2010] support the traditional twin deficit hypothesis in the US, whereas Kim and Roubini [2008] support the opposite in the US, which means that budget deficits lead trade surpluses, called the twin divergence hypothesis. Furthermore, a large body of literature detects structural changes of the relation between budget balance and external balance in the US, but previous studies ignore those structure breaks or focus on the post-Bretton Woods era to avoid the effects of the exchange rate regime shift. However, it is not sufficient to consider only the post Bretton Woods periods since some studies such as Mann [2002] suggest that there are other structural breaks on the relation in early 1990s in the US.<sup>40</sup>

---

<sup>39</sup>For example, the budget balance-to-GDP ratio in US is -9% and the trade balance-to-GDP ratio is -3.5% in 2010.

<sup>40</sup>Bilbiie et al. [2008] also show that effects of government spending on the economy has been changed after 1980s in U.S. due to several reasons, though they do not consider external balance variables such as trade balances. However, it is natural to think that the effects of spending on external variable are possibly changed.

In order to evaluate effects of several structural changes on the relationship between budget balances and external balances in the US, I estimate a time varying structural VAR (TVP-VAR) model proposed by Primiceri [2005] using post-World War II data for the US economy. The estimation results are summarized by the following four.

The first one is that increasing in government spending leads trade deficits in the Bretton Woods era generally.

The second one is that in contrast to the results in the Bretton Woods era, increasing in government spending induces trade surpluses in the post-Bretton Woods era.

The third one is anomaly in the 1980s. Trade deficits are caused by an increase in government spending in 1980s in spite of adopting a floating exchange regime in the US.

Finally, the response of terms-of-trade (defined by the ratio of the export price to the import price as a proxy of internal relative price) to an increase in government spending is stable across the periods: Appreciation (increasing in value of real dollar) after initial small depreciation.

The empirical results 1 and 2 indicate that the traditional twin deficit hypothesis holds under a fixed exchange regime, but the twin divergence hypothesis holds under a floating exchange rate regime. The result 3 means that the relationship between budget balances and trade balances depend not only on exchange rate regimes but also other factors.

To provide some insights about the empirical results, I construct a new Keynesian small open economy model incorporated Rule-of-Thumb (ROT) consumers proposed by Gali et al. [2007b]. The core mechanism to understand the difference across exchange rate regimes (results (1) and (2)) could be the response of the monetary

authority to inflation. In the model, a rise in government spending leads a rise in aggregate demand, and that puts upward pressures on inflation. Under the floating exchange rate regime and Taylor rule, real interest rate rises since the monetary authority increases nominal interest rate to respond to inflation, and that crowds out Ricardian consumers' consumption. Though ROT consumers' consumption increases in response to an increase in spending, total aggregate consumption decreases in the floating exchange regime. Under the fixed exchange regime, however, the first goal of the monetary authority is stabilizing nominal exchange rate, and therefore the monetary authority does not respond to inflation caused by government spending. Consequently, real interest rate less increases relative to a floating exchange rate regime case, so that Ricardian consumers less decreases their consumption relative to a floating exchange rate case. In other words, the response of aggregate consumption in the fixed exchange rate case could be positive in contrast to that in the floating exchange rate case. Thus trade balances could be deteriorated under the fixed exchange rate case since the positive response of aggregate demand leads an increase in import. Furthermore, terms-of-trade is closely related to Ricardian consumers' consumption in the model, so that an exogenous change in spending always leads appreciation of terms-of-trade since consumption of Ricardian consumers always decreases in response to an exogenous change in government spending.

Additionally, the potential channel to explain anomaly in the 1980s (result 3) is that slow adjusted tax. When the tax rule is less sensitive to an increase in government spending, it stimulates ROT consumers' consumption since their disposable income increases and therefore imports increase and trade balances are deteriorated.

There are a huge number of empirical literature on the relation between budget deficits and trade deficits. However, those literature provide somewhat mixed evidence. Some studies using single equation approaches such as Roubini [1988] and

Chinn and Prasad [2003] support the twin deficit hypothesis, but Gruber and Kamin [2007] provide the evidence to support that the effect of budget deficits on current account deficits is small and statistically insignificant. Several studies using structural VAR models also provide different results. For example, Corsetti and Müller [2006], Kim and Roubini [2008], Müller [2008], and Enders et al. [2011] support the twin divergence hypothesis with US data, whereas Monacelli et al. [2010], Beetsma et al. [2008], and Ravn et al. [2007] provide the evidences which support the traditional twin deficit hypothesis.<sup>41</sup> Also, there are several literatures which emphasize an importance of different conditions of the economy. Corsetti and Müller [2006] show the degree of openness matters. They show that the effects of budget deficit on current account deficit is limited in less open countries such as US, but in open economy such as Canada budget deficits tend to lead trade deficit. Country panel data studies such as Corsetti et al. [2012b], and Ilzetzi et al. [2013] show that the effects of a government spending shock on trade balance (or current account) depend on the state of economy such as exchange rate regimes, and financial market conditions. Especially, Corsetti et al. [2012b] show that twin deficit is common under a fixed exchange rate regime, while the opposite occurs under a floating exchange rate regime. Born et al. [2013b] also show that a nominal exchange rate regime is important to determine the relationship between fiscal and trade balance with OECD panel data. In addition, several studies using DSGE model such as Erceg et al. [2005] shows that a rise in the budget deficit leads trade deficit in the US.

The responses of an international relative price such as terms-of-trade to a fiscal shock are also mixed. In Corsetti and Müller [2006], for example, terms-of-trade depreciates after increasing in budget deficits, whereas Monacelli and Perotti [2008] and Müller [2008] show appreciation of terms-of-trade after an exogenous increase in

---

<sup>41</sup>Hebous [2011] provides a nice summary on results in several VAR studies.

government spending.<sup>42</sup>

However, several literature provide evidence on structural breaks on the relationship between budget deficits and external deficits at least in US, but previous studies do not consider this problem seriously. For example, Leachman and Francis [2002] argue that the collapse of Bretton Woods seriously alter the relation between budget balances and external balances. Mann [2002] observes that the relation between budget and external balance has been changed after the early 1990. Hatemi-j and Shukur [2002] find a structural break on relationship between budget balance and external balance in 1989 with some econometrics test and US data. Nevertheless, most empirical studies do not evaluate the effects of structural breaks. Early studies ignores effects of structural changes. They pooled the Bretton Woods and the post-Bretton Woods data and estimate equations. Moreover, recent VAR studies only focus on the post-Bretton Woods era (the periods after 1973 or 1980) to avoid effects of structural changes due to the exchange rate regime shift. However, it is not sufficient to avoid the effects of structural breaks since there seems to be other structural changes, at least, in the US. In contrast to previous literatures, this research explicitly accounts for the effects of structural breaks using the time varying structural VAR model.

Also, a number of studies employ time varying structural VAR (TVP-VAR) models to capture structural changes and time varying relations. In particular, studies on monetary policy such as Cogley and Sargent [2005] and Primiceri [2005] intensively utilize TVP-VAR models. In a recent day, Benati and Mumtaz [2007] investigate the time varying driving force of the US economy with the TVP-VAR model, and Baumeister and Peersman [2013] study time varying effects of oil shock on the US

---

<sup>42</sup>In contrast to term of trade, the response of real exchange rate is consistent across different VAR studies: depreciation. See Kim and Roubini [2008], Monacelli et al. [2010], and Enders et al. [2011].

economy. Nevertheless, few literatures on fiscal policy employ this method. Kirchner et al. [2010] use the TVP-VAR and the recursive identification method to investigate time varying effects of government spending shock on the EU economy. Pereira and Lopes [2010] also use the TVP-VAR and the non-recursive Blanchard and Perotti [2002] identification method to identify US tax and government spending shock. However, none of those literatures considers external balance or international price variables such as trade balance, terms-of-trade, or real exchange rate. To the best of my knowledge, Rafiq [2010] is the only one which considers the time varying relation between budget deficits and current account deficits, but this study only focuses on the post-Bretton Woods era, so that we can not observe the effects of the exchange rate regime shift. Thus this research can provide new aspects of time varying effects of fiscal policy on external variables.

### III.2 Data, Econometric Method, and Identification

#### III.2.1 Econometric Method

Consider the following reduced form VAR model.

$$y_t = c_t + B_{1,t}y_{t-1} + \cdots + B_{k,t}y_{t-k} + u_t \quad t = 1, \cdots T \quad (23)$$

where  $y_t$  is an  $n \times 1$  vector of the endogenous variables,  $c_t$  is an  $n \times 1$  vector of time varying coefficients related with constant term,  $B_{j,t}$ ,  $j = 1, \cdots, k$  are  $n \times n$  vectors of time varying coefficients,  $u_t$  are unobserved shocks with mean zero and the variance-covariance matrix  $\Omega_t$  and  $n$  is the number of endogenous variables. I allow not only time varying coefficients but also heteroskedastic innovations following Primiceri [2005] and Cogley and Sargent [2005] to capture structural changes as well

as change in underlying stochastic distributions in the model.<sup>43</sup> Using a triangular factorization, the variance-covariance matrix  $\Omega_t$  can be factorized as follows:

$$A_t \Omega_t A_t' = \Sigma_t \Sigma_t' \quad (24)$$

where  $A_t$  is the lower triangular matrix with ones on main diagonal<sup>44</sup> and  $\Sigma_t$  is the diagonal matrix given by

$$A_t = \begin{bmatrix} 1 & 0 & \cdots & 0 \\ \alpha_{21,t} & 1 & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ \alpha_{n1,t} & \cdots & \alpha_{nn-1,t} & 1 \end{bmatrix}, \Sigma_t = \begin{bmatrix} \sigma_{1,t} & 0 & \cdots & 0 \\ 0 & \sigma_{2,t} & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & \sigma_{n,t} \end{bmatrix}$$

The equation (23) can be rewritten with the factorization as follows:

$$y_t = c_t + B_{1,t}y_{t-1} + \cdots + B_{k,t}y_{t-k} + A_t^{-1}\Sigma_t\varepsilon_t \quad (25)$$

$$Var(\varepsilon_t) = I_n$$

where  $Var$  is an variance-covariance matrix and  $I_n$  denotes an  $n \times n$  identity matrix. Stacking in a vector  $B_t$  all the time varying coefficients in equation (25) leads the following relation.

$$y_t = X_t' B_t + A_t^{-1} \Sigma_t \varepsilon_t \quad (26)$$

$$X_t' = I_n \otimes [1, y_{t-1}', \cdots, y_{t-k}']$$

---

<sup>43</sup>Stock [2001] points out that it is possible to exaggerate the time variation in VAR coefficients without heteroskedastic innovations.

<sup>44</sup>Allowing time varying  $A_t$  is crucial for the time varying structural VAR model. It can capture simultaneous interactions among endogenous variables in contrast to time invariant  $A_t$ . Time invariant  $A_t$  implies that effects of an innovation of one endogenous variable on other variables are fixed. See Primiceri [2005].

where  $\otimes$  is the Kronecker product.

The evolution of the state vector of coefficients  $B_t$ ,  $\alpha_t$  the collection of the non-zero and non-one elements of  $A_t$ (stacked by row) and  $\sigma_t$  which is the collection of the diagonal elements of  $\Sigma_t$  are specified as follows:

$$B_t = B_{t-1} + \nu_t \quad (27)$$

$$\alpha_t = \alpha_{t-1} + \zeta_t \quad (28)$$

$$\log \sigma_t = \log \sigma_{t-1} + \eta_t \quad (29)$$

$B_t$  and  $\alpha_t$  follow random walks and  $\sigma_t$  is assumed to follow geometric random walks.<sup>45</sup> All those processes are similar to Primiceri [2005] and Kirchner et al. [2010].

The joint distribution of innovations of  $\varepsilon_t$ ,  $B_t$ ,  $\alpha_t$  and  $\sigma_t$  is assumed to be joint normal and its variance-covariance matrix is given by

$$V = Var \left( \begin{bmatrix} \varepsilon_t \\ \nu_t \\ \zeta_t \\ \eta_t \end{bmatrix} \right) = \begin{bmatrix} I_n & 0 & 0 & 0 \\ 0 & Q & 0 & 0 \\ 0 & 0 & S & 0 \\ 0 & 0 & 0 & W \end{bmatrix} \quad (30)$$

The block diagonal assumption of  $V$  is not essential but it has two desired properties. The first one is reducing the number of parameters to be estimated. Allowing correlations among innovations is easily implemented with small modifications but it gives an over-parametrization problem. The block diagonal assumption for  $V$  prevents ill-identified parameters. The second advantage is the structural interpretation. If all

---

<sup>45</sup>The advantages and disadvantages of (geometric) random walks assumption are well described in Primiceri [2005] and Kirchner et al. [2010]. The main advantage of random walks is that it reduces the number of parameters in the estimation process.



innovations are correlated, it is not easy to identify the meaning of shocks.<sup>46</sup>

Additionally,  $S$  is assumed to be the block diagonal matrix as in Primiceri [2005] and Baumeister and Peersman [2013].<sup>47</sup> The assumption implies that the contemporaneous relations among variables evolve independently in each equation. It facilitates estimating  $A_t$  row by row, which simplifies the estimation algorithm.<sup>48</sup>

### III.2.2 Estimation Method

In this section, I briefly describe the estimation algorithm and the choice of the priors. The main algorithm is based on Primiceri [2005] and Cogley and Sargent [2005] with minor modifications for the calibration of the priors. Detailed description of the estimation procedures and the calibration of the priors is left to appendix A. As mentioned in Primiceri [2005] and Kirchner et al. [2010], Bayesian method with Gibbs sampling is suitable way to estimate a time varying coefficients model. Gibbs sampling is conducted by the following four steps.

The first step is for VAR coefficients  $B_t$ . Conditional on the data and a history of  $A_t$ ,  $\Sigma_t$  and hyperparameters, the measurement equation (26) is a standard linear-Gaussian model. As shown in Carter and Kohn [1994], the VAR coefficients can be drawn from the Kalman filter and the backward recursion.

---

<sup>46</sup>Kirchner et al. [2010] claim that the independence of  $\Omega_t$  and hyperparameters( $Q$ ,  $S$  and  $V$ ) is reasonable because the innovations of VAR model( $u_t$ ) capture short-term events such as business cycles events or policy shocks in contrast to the innovations of parameters( $\nu_t$ ,  $\zeta_t$ ,  $\eta_t$ ) which capture long-term events such as institutional changes. Such short-term events are not necessarily correlated with long term institutional events.

<sup>47</sup>The model includes four variables in this paper. Thus the structure of  $S$  is given by

$$S = \begin{bmatrix} S_1 & 0_{1 \times 2} & 0_{1 \times 3} \\ 0_{2 \times 1} & S_2 & 0_{2 \times 3} \\ 0_{3 \times 1} & 0_{3 \times 2} & S_3 \end{bmatrix}$$

where  $S_1 = Var(\zeta_{21,t})$ ,  $S_2 = Var([\zeta_{31,t}, \zeta_{32,t}]')$ ,  $S_3 = Var([\zeta_{41,t}, \zeta_{42,t}, \zeta_{43,t}]')$  and  $0_{i \times j}$  is the  $i \times j$  matrix in which all elements are zero.

<sup>48</sup>Detailed discussions in appendix A and also in Baumeister and Peersman [2013]

The second step is for covariance states  $A_t$ . Conditional on the data and a history of  $B_t$ ,  $\Sigma_t$  and  $V$ , the measurement equation (26) can be rewritten as  $A_t u_t = \Sigma_t \varepsilon_t$  where  $u_t$  is observable. This is a standard linear-Gaussian system with independent equations given the lower triangular matrix  $A_t$  and the block diagonal matrix  $S$ . The Kalman filter and the backward recursion can be applied to sample  $A_t$  equation by equation.

The third step is volatility states  $\Sigma_t$ . Conditional on the data and a history of  $B_t$ ,  $A_t$  and  $V$ , the measurement equation (26) is non-linear and non-Gaussian but it is easily converted to a linear one by squaring and taking log of each elements. However, the transformed system is still non-Gaussian, so that it is difficult to use the standard smoother. Fortunately, the transformed system can be approximated to a linear-Gaussian system by Kim et al. [1998], which facilitates applying the standard smoother proposed by Carter and Kohn [1994] to the final approximated system to draw the elements of  $\Sigma_t$ .

The fourth step is for hyperparameters  $V$ . Conditional on  $B_t$ ,  $A_t$ ,  $\Sigma_t$  and the data, the sampling of the hyperparameter  $V$  is standard since each block of  $V$  has an independent inverse-Wishart posterior given the proper priors.

Gibbs sampling with sufficiently large iterations and a long burn-in period delivers a realization from the joint posterior distribution. In this paper, I generate 100,000 draws and burn-in the first 50,000. Of the remaining 50,000, every 10th draw is kept to mitigate the autocorrelation of draws similar in Kirchner et al. [2010]. Overall, Gibbs sampling works well and the chain seems to be well mixed.

The choice of the priors is somewhat standard as in Primiceri [2005], Benati and Mumtaz [2007] and Koop et al. [2009] but there are minor differences. First, the selection of degrees of freedom of the priors is more conservative. I allow the minimum number for the priors to be proper as in Benati and Mumtaz [2007] and

Kirchner et al. [2010] to minimize effects of the priors. Secondly, in most TVP-VAR studies, priors are calibrated with OLS estimators of an initial “trained data” which is then discarded. As opposed to previous studies, I use the full sample OLS estimators to calibrate the priors following Canova and Ciccarelli [2009]. There are two reasons to use the full sample method. First, some initial data points(usually 8 to 10 years) should be sacrificed with the trained data method, that is, some data points of Brettonwoods system are discarded. A short sample of Brettonwoods can mislead the effects of a fixed exchange rate regime. Furthermore, the full sample method minimizes the uncertain involved in calibrating the priors properly as mentioned in Canova and Ciccarelli [2009].<sup>49</sup> Details are in appendix A.

Another issue is imposing the stability condition on the VAR coefficients  $B_t$ . Since Gibbs sampling does not guarantee the stability of each draw of  $B_t$ (the eigenvalues of  $B_t$  are in the unit circle), Cogley and Sargent [2005] impose the stability condition on the time varying coefficients. In Cogley and Sargent [2005], the variable of concern is inflation and the FED conducts monetary policy in a proper way to ruling out explosively inflation paths. As discussed in Kirchner et al. [2010] and Pereira and Lopes [2010], however, the fiscal authority is not necessarily concerned about the stability of the economy unlike the monetary authority. Following their arguments, I do not impose the stability condition on the VAR coefficients  $B_t$ .

### III.2.3 Data

The TVP-VAR model consists of four variables of the US economy: log of per capita real government spending(GOV), log of per capita real GDP(GDP), net export to

---

<sup>49</sup>Kirchner et al. [2010] and Rafiq [2012] also use full sample OLS estimators to calibrate their priors.

GDP ratio(NX), log of terms-of-trade(TOT).<sup>50</sup> The sample starts from 1947.Q1 to 2013.Q2. Government spending and GDP are deflated with GDP deflator and divided by mid-period population. Government spending is the general government spending which includes the general government's consumption and investment.<sup>51</sup> Net exports is defined by the difference between exports and imports, which means that negative net exports is equivalent to trade deficit. Terms-of-trade is the ratio of export price to import price, which implies that increasing in terms-of-trade means appreciation in the value of US dollar measured in real term. All variables are taken from Bureau of economic analysis (BEA) except terms-of-trade and GDP deflator taken from FRED in September 2013 and pre-detrended with quadratic time polynomials to focus on cyclical components following Pereira and Lopes [2010].<sup>52</sup>

### III.2.4 Identification and Interpretation

In the TVP-VAR study, the exogenous government spending shock is identified by assuming that government spending does not respond to other variables (GDP, NX and TOT) within a quarter. The identification scheme is widely adopted in VAR literatures on fiscal policy such as Fatás and Mihov [2001], Blanchard and Perotti [2002], Monacelli et al. [2010] and Kirchner et al. [2010].<sup>53</sup> This identification strategy seems reasonable because the government spending series used in this paper does not include transfers which automatically vary over business cycles. Moreover, lags of

---

<sup>50</sup>I include terms-of-trade as a proxy of the relative international price instead of real exchange rate because the time span of real exchange rate does not cover the sample periods. BIS real effective exchange rate which is the longest starts the final quarter in 1963. Corsetti and Müller [2006] and Müller [2008] also use terms-of-trade as a proxy of the international relative price. Also, the variables which I use are similar in Ilzetzi et al. [2013] though they use current account as a proxy of external balance and real exchange rate instead of terms-of-trade.

<sup>51</sup>This series does not include either transfers or interest payment.

<sup>52</sup>For robustness checks, I also estimate the model with the level data. The results are not sensitive to the detrend method.

<sup>53</sup>Especially, Kirchner et al. [2010] use this identification method in their TVP-VAR study on fiscal policy in EU.

policy decisions can prevent policy makers' instantaneous responses to the state of the economy. With the identification scheme, the exogenous government spending shock is easily identified by ordering government spending first in the system. Specifically,

$$u_t = C_t \varepsilon_t, \quad C_t C_t' = \Omega_t \quad (31)$$

where  $C_t$  is the mapping between reduced form innovations  $u_t$  and structural shocks  $\varepsilon_t$ . By definition of  $A_t$  and the identification strategy,  $C_t = A_t^{-1} \Sigma_t$  as described in Primiceri [2005].

It is worth pointing out that this identification strategy is not undebatable. The narrative approach to identify government spending shocks such as Ramey and Shapiro [1998] and Ramey [2011a] often yields different results to compare with the structural VAR approach. For example, the narrative approach tends to predict the negative response of private consumption and real wages to increasing in government spending while the structural VAR studies show the opposite. Ramey [2011a] points out that the identified government spending shocks by the structural VAR approach are anticipated by the private sector, which leads the difference (or an incorrect impulse response). However, Mertens and Ravn [2010] who develop the new method which is robust to the anticipation effects show that the anticipation effects are not a serious problem in practice. They cannot find an evidence to support that the difference is due to the anticipation effects. Also, Fisher and Peters [2010] build the new narrative measure using the accumulated excess returns of large US military contractors and estimate the effects of government spending shocks. The estimation results are consistent with the results of the structural VAR approach: increasing in private consumption and real wages (after small initial decline). Furthermore, I estimate the model including Ramey [2011a]'s new variable to control the anticipa-

tion effects, and the results show the same implications as in the model without the news variable. To economize the number of parameters to estimate, I use the model without the news variables.

Another issue is the choice of the lag length for the econometric model. The model in this paper includes four lags which is longer than most of TVP-VAR literatures such as Primiceri [2005], Cogley and Sargent [2005], Benati and Mumtaz [2007] and Kirchner et al. [2010] which include two lags.<sup>54</sup> The choice of an appropriate lag length is important in structural VAR studies on fiscal policy because the identifying strategy uses the time lag of policy decisions. If the structural VAR model includes too short lags, it cannot fully capture delayed effects of change in other macroeconomic variables on government spending.<sup>55</sup> Also for richer dynamics, a sufficient lag-length is important. At the same time, including longer lags in the TVP-VAR means that the number of parameters to be estimated increases exponentially, which can yield ill-identified parameters. Thus in order to minimize the over-parametrization and to control the time lag of policy decisions properly, the lag length is set to be four which is slightly longer than that in other TVP-VAR literatures.

---

<sup>54</sup>Baumeister and Peersman [2013] use four lags in their TVP-VAR study on time-varying effects of oil shock

<sup>55</sup>Born and Müller [2012] provide the evidence on how long the policy decision lag is. They test whether the restriction on the contemporaneous response of government spending to other macroeconomic variables is valid or not with econometric methods using US, UK, Canada and Australia data. They conclude that the restriction can not be rejected even with annual frequency data, which implies that the lag of policy decisions can be longer than a year. Beetsma et al. [2009] also have similar results with the data of several countries in EU. Moreover, most of VAR studies on fiscal policy such as Blanchard and Perotti [2002] and Fatás and Mihov [2001] include four lags with quarterly data though they use the traditional time-invariant VAR model.

### III.3 Estimation Results

This section is organized as follows. Section III.3.1 presents the estimation results of the traditional time invariant structural VAR with two sub-periods as preliminary evidences on structural breaks between the Bretton Woods and post-Bretton Woods. Next, section III.3.2 presents the estimation results from the time varying structural VAR model to investigate the effects of structural breaks more carefully.

#### III.3.1 Preliminary Evidences on Structural Breaks: Sub-sample Analysis

In order to provide preliminary evidences on structural change between the Bretton Woods and the post-Bretton Woods, the data are divided by two sub-periods: 1947.Q1 - 1972.Q4 and 1980.Q1-2013.Q2 and for each sub-period the time invariant structural VAR is estimated.<sup>56</sup> Figure 11 shows the estimated impulse response to 1% increasing in exogenous government spending for each sub-period. The panels in the first column show the response in the Bretton Woods era while the panels in the second column show the response in the post-Bretton Woods era.

In the first row in figure 12, increasing in government spending leads trade deficit in the Bretton Woods while the opposite occurs in the post-Bretton woods. In the Bretton Woods, the initial response of trade balance is positive. However, the size is small and the response turns to negative soon. After 7 quarters, trade balance drops 0.15 percent points and goes back to the trend. Unlike the Bretton Woods, the initial reaction of trade balance is negative but turns to positive soon in the post-

---

<sup>56</sup>For the time invariant structural VAR, I use the same identification mechanism explained in section . Additionally, the time invariant VAR includes original four variables (GOV-GDP-NX-TOT) and two additional variables: budget balance to GDP ratio and 3 month treasury bill rate. I also include 4 lags, linear and quadratic time trend for the estimation. The 4-variable (GOV-GDP-NX-TOT) time invariant structural VAR model also delivers similar results. Moreover, increasing in government spending always leads budget deficit in both periods but budget balance deteriorates more in the post-Bretton Woods era.

Bretton Woods. After the peak response in 4th quarter (increasing 0.12 percent points), trade balance goes back to the trend. This result is matched to Corsetti et al. [2012b]. They estimate several state-dependent effects of government spending with OECD panel and show that increasing in government spending leads trade deficit under a fixed exchange rate regime while the opposite occurs under a floating exchange rate regime.<sup>57</sup>

Unlike the response of trade balance, the reaction of terms-of-trade (in the second row) seems to be similar in both periods: appreciation in short run and depreciation in long run.<sup>58</sup> The initial response of terms-of-trade in Bretton woods is slightly below zero but turns to positive soon. After the peak response in 6th quarter (0.13% appreciation), the response starts to decline. The reaction turns to negative after 9th quarter, terms-of-trade goes back to the trend slowly after 15th quarter. Similarly, the initial response is negative in the post-Bretton Woods but size is larger than that in the Bretton Woods. After the peak response in 4th quarter (increased by 0.12%), the response turns to negative after 5th quarter and goes back to the trend slowly. In general, the basic pattern in the response of terms-of-trade is similar in both sub-periods but appreciation in terms-of-trade is larger and persistent in the Bretton Woods.

The panels in the third row show the response of GDP to government spending. The stimulus effect of government spending is much stronger and more persistent in the Bretton Woods than that in the post-Bretton Woods. In particular, GDP responds positively to government spending only in first and second quarter after the shock in post-Bretton Woods. This result is similar to Perotti [2004] and Bilbiie

---

<sup>57</sup>In contrast to Corsetti et al. [2012b], Ilzetzi et al. [2013] and Born et al. [2013b] show that the response of external balance is not different across nominal exchange rate regimes.

<sup>58</sup>In Müller [2008] and Monacelli and Perotti [2008], terms-of-trade appreciates after increasing in government spending in US though they consider only the post-Bretton Woods era.



et al. [2008]. Their model also predicts weak and short-lived stimulus effects of government spending after early 1980s. However, the weak and short-lived stimulus effects disappear in the TVP-VAR model. Detailed discussion is in section .

Overall, the results of the time invariant structural VAR model indicate that the twin deficit hypothesis seems to be reasonable in the Bretton Woods while twin divergence may occur in the post-Bretton Woods, which implies that nominal exchange rate regimes have an important role to determine the relation between budget balance and external balance. Meanwhile, the response of terms-of-trade to government sending is not quite different at least qualitatively across nominal exchange rate regimes.

### III.3.2 Unveiling Time Variation: Time Varying Structural VAR

In this section, the estimated time varying impulse response to 1% increasing in government spending is reported. Figure 13 presents the time profile of the response of trade balance. The profile shows that the response of trade balance are generally below zero in the Bretton Woods after mid 1950s but it starts to rise after collapse of the Bretton Woods (1973) and turns to positive in the mid and late 1970s. However, the response begins to decrease and turns to negative in the early 1980s. Finally, the sign of the response is changed to positive after the late 1980s. The time varying pattern is more clear in Figure 14. The median response of trade balance is negative in most horizons of the impulse response (the negative peak response is around  $-0.1$  percent point) and reverts back to trend with a small overshooting under a peg system and in some periods of the 1980s. However, trade surplus (the positive peak response is around  $0.15$  percent point) is more common by increasing in government spending in most periods of the post-Bretton Woods.

To sum up, the time varying pattern of the response of trade balance indicates

that an unanticipated government spending shock induces trade deficit under a fixed exchange rate regime generally whereas trade surplus is induced under a flexible exchange rate regime.<sup>59</sup> Those patterns are consistent with the results from the time invariant structural VAR with sub-samples in section . In addition, the TVP-VAR model delivers the new finding: the response in the 1980s is abnormal. Despite a flexible exchange rate regime is adopted in this period, trade deficit is caused by positive government spending shock.

The response of terms-of-trade is stable across the year: appreciation after initial small depreciation. Figure 14 and 15 clearly show that the response of terms-of-trade is negative initially (except some periods in the early 1950s and the mid 2000s), but it turns to positive soon and reverts back to the trend very slowly. This pattern is also similar to the time invariant VAR results. The size of initial depreciation is between 0.1% and 0.2% in most periods and the size of maximum appreciation rate is around 0.5% in several periods.

Figure 16 and 17 present the time profile of the response of GDP to government spending. The size of the initial response is almost the same in every period, which is in line with Pereira and Lopes [2010]. The contemporaneous response of GDP to 1% increasing in government spending is around 0.14%. Taking into account the average government spending share to GDP(20%), the government spending multipliers is around 0.7 on impact.<sup>60</sup> Unlike the time invariant VAR evidence, however, the stimulus effects are not less persistent after the early 1980s. The evidence from the TVP-VAR indicates that the response of GDP stays below zero longer in only

---

<sup>59</sup>Note that the positive response of trade balance before mid 1950s can be caused by the war(World War II) effects. The recovery of Europe and Japan started in 1950s. Thus before mid 1950s, US is a dominant industrial country and the pattern of US trade balance is distorted by the effects of the war. See Branson et al. [1980]. I focus on the period after the mid 1950s in this paper.

<sup>60</sup>In Hall [2009], the evidence from VAR studies finds the output multiplier is between 0.5 and 1.

some periods of the 1980s. Figure 15 shows that the response of GDP turns to negative after 5 or 6 quarters and then reverts back to trend after 3 years in most periods. However, the response still stays negative region after 3 years in the 1980s. Also, figure 16 shows that the negative peak response of GDP is around -0.1 in the 1980s which is smaller than that in other periods. Pereira and Lopes [2010] also find that stimulus effects of government expenditure do not vary so much over time in their TVP-VAR study. They argue that rolling sample estimations may exaggerate the actual drift, especially the effects of spending shock, because of lack of the smoothing process. VAR models with sub-samples are also sensitive to choice of sub-periods. Thus earlier studies such as Perotti [2004] and Bilbiie et al. [2008] possibly overestimate the instability of effects of government expenditure.

Figure 18 and 19 report the response of government spending shock to government spending shock. After the early 1980s, the response of government spending increases slightly more than that in earlier periods but the response of government spending is somewhat stable across the time.

#### III.4 Discussion

From the results of the TVP-VAR and the time invariant structural VAR in section III.3, the following four empirical facts about the behavior of trade balance and terms-of-trade are obtained.

The first one is that increasing in government spending leads trade deficits in the Bretton Woods era generally.

The second one is that in contrast to the results in the Bretton Woods era, increasing in government spending induces trade surpluses in the post-Bretton Woods era.

The third one is anomaly in the 1980s. Trade deficits are caused by an increase in government spending in 1980s in spite of adopting a floating exchange regime in the US.

Finally, the response of terms-of-trade (defined by the ratio of the export price to the import price as a proxy of internal relative price) to an increase in government spending is stable across the periods: Appreciation (increasing in value of real dollar) after initial small depreciation.

In order to provide potential explanations for the empirical findings, I construct the new Keynesian small open economy based on Corsetti et al. [2009] and Corsetti et al. [2011]. In section III.4.1, and III.4.2, I explain the theoretical model. In section III.4.3, I examine the effects of change in a nominal exchange regime on trade balance and terms-of-trade and provide some structural explanations. In section III.4.4, I investigate the effects of slow adjustment of tax and spending reversal to provide potential channels to understand the mysterious twin deficits in the 1980s.

### III.4.1 Theoretical Model

The model is based on the small open economy new Keynesian model with government spending proposed by Corsetti et al. [2009] and Corsetti et al. [2011].

#### III.4.1.1 Households

There is a continuum of households  $[0, 1]$  which consists of two types of agents: Asset holders and non-asset holders. Asset holders ( $1 - \lambda$  fraction of households) trade the one-period domestic bonds and the international bonds given their price. While non-asset holders ( $\lambda$  fraction of households) do not participate in either domestic or international bond markets. This assumption is similar to Gali et al. [2007b] and Bilbiie et al. [2008].

A representative asset holder, indexed with a subscript  $A$ , maximizes her life-time utility subject to the budget constraint. The life-time utility is given by

$$E_t \sum_{i=0}^{\infty} \beta^i \left( \frac{C_{A,t+i}^{1-\gamma}}{1-\gamma} - \frac{H_{A,t+i}^{1+\phi}}{1+\phi} \right) \quad (32)$$

where  $C_{A,t}$  is consumption in time  $t$  and  $H_{A,t}$  is labor supply.  $\beta$  is the discount factor of the representative asset holder,  $\gamma > 0$  is the relative risk-aversion coefficient and  $\phi > 0$  is the inverse Frisch elasticity of labor supply. The period-by-period budget constraint is as follows:

$$P_t C_{A,t} + R_t^{-1} A_{t+1} + R_{F,t}^{-1} \frac{B_{t+1}}{\varepsilon_t} = W_t H_{A,t} + A_t + \frac{B_t}{\varepsilon_t} + \Gamma_t - T_t \quad (33)$$

$P_t$  is the corresponding price index to the consumption good,  $A_t$  are the one-period nominal domestic government bonds and  $R_t$  is the corresponding gross nominal interest rate.  $B_t$  are the one-period nominal international bonds,  $R_{F,t}$  is the corresponding gross nominal interest rate and  $\varepsilon_t$  is the nominal exchange rate measured in units of foreign currency per domestic currency. Moreover,  $W_t$  is the nominal wage,  $\Gamma_t$  is the profits from intermediate good firms and  $T_t$  is the nominal lump-sum transfers. It is assumed that domestic bonds are not traded in international financial markets as in standard small open economy model such as Gertler et al. [2007]. Since I assumed the imperfect international financial market, a closing technique is needed to ensure stationarity of the model. Following Schmitt-Grohé and Uribe [2003] and Kollmann [2002], I assumed that  $R_{F,t}$  depends on the aggregate level of foreign bonds:

$$R_{F,t} = R_t^* - \chi \frac{B_{t+1}}{\varepsilon_t P_t Y_t} \quad (34)$$

$\chi$  is the debt-elasticity of interest rate,  $R_t^*$  is the gross world nominal interest rate

and  $Y_t$  is the real GDP. The representative asset holder chooses labor supply, consumption, quantity of domestic and international bonds to maximize her life time utility. The optimality condition for labor supply is given by

$$\frac{W_t}{P_t} = \frac{H_{A,t}^\phi}{C_{A,t}^{-\gamma}} \quad (35)$$

Also, the optimality conditions for intertemporal choices (consumption, domestic and international bonds) are given by

$$C_{A,t}^{-\gamma} = \beta E_t \left[ C_{A,t+1}^{-\gamma} R_t \frac{P_t}{P_{t+1}} \right] \quad (36)$$

$$C_{A,t}^{-\gamma} = \beta E_t \left[ C_{A,t+1}^{-\gamma} R_{F,t} \frac{\varepsilon_t}{\varepsilon_{t+1}} \frac{P_t}{P_{t+1}} \right] \quad (37)$$

The objective of a representative non-asset holder, indexed with a subscript  $N$ , is maximizing her instantaneous utility which is given by

$$\frac{C_{N,t}^{1-\gamma}}{1-\gamma} - \frac{H_{N,t}^{1+\phi}}{1+\phi} \quad (38)$$

where  $C_{N,t}$  is consumption and  $H_{N,t}$  is labor supply. Since the representative non-asset holder does not trade bonds and does not have shares of intermediate good firms, her consumption is equal to the disposable income which is the labor income,  $W_t H_{N,t}$ , less the lump-sum taxes,  $T_t$ .

$$P_t C_{N,t} = W_t H_{N,t} - T_t \quad (39)$$

### III.4.1.2 Final Good Firms

The final consumption good  $C_t$  is a composite of domestic intermediate goods and foreign intermediate goods which are produced by a continuum of monopolistic competitive domestic firms and foreign firms, respectively. The final good firms operate in perfect competitive markets and try to minimize their expenditures subject to the following aggregation technology.

$$C_t = \left[ (1 - \omega)^{\frac{1}{\sigma}} \left( \left[ \int_0^1 Y_{D,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}} \right)^{\frac{\sigma-1}{\sigma}} + \omega^{\frac{1}{\sigma}} \left( \left[ \int_0^1 Y_{F,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}} \right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \quad (40)$$

where  $Y_{D,t}(j)$  is a domestic intermediate good produced by  $j$ th domestic intermediate good firm and  $Y_{F,t}(j)$  is a foreign good produced by  $j$ th foreign intermediate good firm.  $\omega$  is the proportion of foreign goods in composite good, which can be interpreted as the degree of openness.  $\sigma$  measures the trade price elasticity and  $\epsilon$  measures the price elasticity of intermediate goods within the same country. Let me define the domestic composite good  $Y_{D,t}$  and the foreign composite good  $Y_{F,t}$  as follows:

$$Y_{D,t} = \left[ \int_0^1 Y_{D,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}}, \quad Y_{F,t} = \left[ \int_0^1 Y_{F,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right]^{\frac{\epsilon}{\epsilon-1}} \quad (41)$$

Then expenditure minimization implies that the associated price indexes of  $Y_{D,t}$  and  $Y_{F,t}$  are

$$P_{D,t} = \left( \int_0^1 P_{D,t}(j)^{1-\epsilon} dj \right)^{\frac{1}{1-\epsilon}}, \quad P_{F,t} = \left( \int_0^1 P_{F,t}(j)^{1-\epsilon} dj \right)^{\frac{1}{1-\epsilon}} \quad (42)$$

The price index of import goods is given by

$$P_{F,t} = \frac{P_t^*}{\varepsilon_t} \quad (43)$$

where  $P_t^*$  is the foreign aggregate price index. By the similar process, the domestic aggregate price index  $P_t$  is

$$P_t = [(1 - \omega)P_{D,t}^{1-\sigma} + \omega P_{F,t}^{1-\sigma}]^{\frac{1}{1-\sigma}} \quad (44)$$

### III.4.1.3 Intermediate Good Firms

There is a continuum of domestic intermediate good firms  $[0, 1]$  which use the following production technology

$$Y_{D,t}(j) = H_t(j) \quad (45)$$

where  $Y_{D,t}(j)$  is the output of  $j$ th firm and  $H_t(j)$  is the labor demand of  $j$ th firm. Intermediate good sector is assumed to be imperfect competitive and each firm sets its own price with Calvo fashion. Thus the profit maximizing problem of  $j$ th firm is as follows:

$$\max E_t \sum_{i=0}^{\infty} \xi^i \Lambda_{t,t+i} [Y_{D,t,t+i}(j) P_{D,t}(j) - W_{t+i} H_{t+i}(j)] \quad (46)$$

where  $1 - \xi$  is the probability of price adjusting and  $\Lambda_t$  is the stochastic discount factor of the representative asset holder. The optimality condition for each intermediate good firm is given by

$$E_t \sum_{i=0}^{\infty} \xi^i \Lambda_{t,t+i} \left[ Y_{D,t,t+i}(j) P_{D,t}(j) - \frac{\epsilon}{\epsilon - 1} W_{t+i} H_{t+i} \right] = 0 \quad (47)$$

Finally, it is assumed that the foreign country has the isomorphic aggregation technology and the law of one price holds at the level of intermediate goods in this model as in Gertler et al. [2007] and Corsetti et al. [2011].



#### III.4.1.4 The Government

The monetary authority adjusts the nominal interest  $R_t$  with the following Taylor-rule under a flexible exchange rate regime.

$$R_t = R + \phi_\pi(\Pi_t - \Pi) \quad (48)$$

where  $R$  is the steady-state nominal interest rate,  $\Pi_t = P_t/P_{t-1}$  is the CPI inflation and  $\Pi$  is the steady-state inflation rate. On the other hands, the monetary authority keeps the change in nominal exchange rate zero under a fixed exchange rate regime, which means that the monetary authority follows the rule given by

$$\Delta\varepsilon_t = \varepsilon_t - \varepsilon_{t-1} = 0 \quad (49)$$

Government spending  $G_t$  is defined by the aggregation of domestic intermediate goods:

$$G_t = \left( \int_0^1 Y_{D,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}} \quad (50)$$

By the cost minimization, the associated price index of government spending is  $P_{D,t}$ . I assumed that government spending is financed by lump-sum taxes  $T_t$  or the one-period government bonds  $D_t$ . Given this assumption, the period-by-period budget constraint of the government is given by

$$R_t^{-1}D_{t+1} = D_t + P_{D,t}G_t - T_t \quad (51)$$

Additionally, it is assumed that government spending follows

$$G_t = (1 - \psi_{gg})G + \psi_{gg}G_{t-1} + \psi_{gd}\frac{D_t}{P_{t-1}} + \eta_t \quad (52)$$

$0 \leq \psi_{gg} \leq 1$  captures the persistence of government spending,  $\psi_{gd} \leq 0$  means the degree of responsiveness of government spending to real government debts and  $\eta_t$  is an exogenous shock of government spending. If  $\psi_{gd}$  is equal to zero, government spending follows a simple  $AR(1)$  process and does not respond to the level of government debts (no spending reversal).

The adjustment process of tax is assumed to be

$$T_{R,t} = (1 - \psi_{tg})G + \psi_{tg}G_t + \psi_{td}\frac{D_t}{P_{t-1}} \quad (53)$$

where  $T_{R,t} = T_t/P_t$  is real taxes.  $0 \leq \psi_{tg} \leq 1$  captures the responsiveness of tax to the government spending and  $\psi_{td} \geq 0$  captures the responsiveness of tax to the level of government debts. If  $\psi_{tg}$  is equal to one, taxes should increase one-for-one to increasing in government spending. The government spending rule and tax adjustment rule are similar to Corsetti et al. [2011] and Corsetti et al. [2012a].

#### III.4.1.5 Equilibrium

In equilibrium, the supply and the demand of each domestic intermediate good firm should be matched. Given households' and government's demands of domestic goods and the volume of exports, the following equation must be satisfied.

$$Y_{D,t}(j) = \left( \frac{P_{D,t}(j)}{P_{D,t}} \right)^{-\epsilon} \left( (1 - \omega) \left( \frac{P_{D,t}}{P_t} \right)^{-\sigma} C_t + \omega \left( \frac{P_{D,t}^*}{P_t^*} \right)^{-\sigma} C_t^* + G_t \right) \quad (54)$$

where  $P_{D,t}^*$  is the price index of domestic goods in terms of the foreign currency and  $C_t^*$  is the foreign consumption index. Let the aggregate output index  $Y_t$  be

$$Y_t = \left( \int_0^1 Y_{D,t}(j)^{\frac{\epsilon-1}{\epsilon}} dj \right)^{\frac{\epsilon}{\epsilon-1}} \quad (55)$$

Using the firm level equilibrium condition and the aggregate output index, the following aggregate relation should hold.

$$Y_t = (1 - \omega) \left( \frac{P_{D,t}}{P_t} \right)^{-\sigma} C_t + \omega \left( \frac{P_{D,t}^*}{P_t^*} \right)^{-\sigma} C_t^* + G_t \quad (56)$$

Moreover, the following aggregate consumption relation and the labor market clearing condition should be hold.

$$C_t = \lambda C_{N,t} + (1 - \lambda) C_{A,t}, \quad H_t = \lambda H_{N,t} + (1 - \lambda) H_{A,t} \quad (57)$$

Given the assumption that domestic bonds are not traded in international financial markets, the domestic asset market clearing condition is as follows:

$$(1 - \lambda) A_t = D_t \quad (58)$$

The terms-of-trade  $S_t$  which is the ratio of export price to import price and real exchange rate  $Q_t$  can be defined

$$S_t = \frac{P_{D,t}}{P_{F,t}}, \quad Q_t = \frac{P_t \varepsilon_t}{P_t^*} \quad (59)$$

Following the definition of the real exchange rate and terms-of-trade, increasing in  $Q_t$  and  $S_t$  means appreciation of the real exchange rate and terms-of-trade (appreciation in domestic currency measured in real term). Finally, trade balance in terms of steady state output is as follows:

$$TB_t = \frac{1}{Y} \left( Y_t - \frac{P_t}{P_{D,t}} C_t - G_t \right) \quad (60)$$

### III.4.2 Calibration

Table 6 summarizes the calibration for the simulation study. The discount factor  $\beta$ , the risk aversion coefficient  $\gamma$  and the inverse Frisch elasticity  $\phi$  are standard. Trade price elasticity  $\sigma$  is assumed to be 0.7 in line with Monacelli et al. [2010] and Born et al. [2013b].<sup>61</sup> The price stickiness parameter  $\xi$  is set to be 0.75 to match with the four quarters average price duration. This number is in line with several literatures such as Gali and Monacelli [2005].

Also, I assume that  $\epsilon$  is equal to 11 to match 10% of the steady state mark up. Taylor coefficient  $\phi_\pi$  is set to be 1.5 which is standard and ensures the rational equilibrium. Following Corsetti et al. [2009], I assume the debt-elasticity of interest rate  $\chi$  is 0.00001 which is also similar to Gertler et al. [2007]. For the fraction of non-asset holders  $\lambda$ , I assume 1/3 for the baseline simulation. Corsetti et al. [2012a] also use the same number and Bilbiie et al. [2008] estimate  $\lambda$  close to 1/3 with 1983 to 2004 US data. Additionally, in order to examine the role of non asset holders in section III.4.4, I use a different number 1/2 for  $\lambda$  and compare with those two results.

The persistence of government spending  $\psi_{gg}$  is set to be 0.9 which is standard. For the simplicity, I assume that the government spending rule is not sensitive to level of debts ( $\psi_{gd} = 0$ ) for the baseline simulation. Moreover, for the baseline simulation, the debt-responsiveness for tax  $\psi_{td}$  is assumed to be 0.02 which is in line with Corsetti et al. [2011] and the responsiveness of government spending for tax  $\psi_{tg}$  is 0.5 which is the same in Corsetti et al. [2009]. To study the effects of slow-adjusting taxes in section III.4.4, I also use a different number 0 for  $\psi_{tg}$ . The steady state share of

---

<sup>61</sup>There is no consensus about this parameter. Backus and Smith [1993] use 1.5 for their simulation while Born et al. [2013b] use 1/3 for the quantitative results. Monacelli et al. [2010] shows that the response of trade balance to government spending shock heavily depends on this parameter value. To match with the empirical results, I choose relatively small number 0.7. Detailed discussion in Monacelli et al. [2010].

government spending to output is assumed to be 20% and the import share  $\omega$  is set to be 0.2 to match with US time series data.

Finally, for the simulation, the model is linearized around the zero government debt and zero inflation steady state. All foreign variables are assumed to be constant.

### III.4.3 Floating Exchange Rate Regime versus Fixed Exchange Rate Regime

In this section, I examine the effects of change in a nominal exchange rate regime on trade balance and terms-of-trade. Quantitative results are measured in deviations from the steady state scaled by the steady state output except terms-of-trade and inflation. For the impulse response of terms-of-trade and inflation, the results are measured in percentage deviations from the steady state.

The second panel in the first row in figure 20 shows that the response of trade balance to increasing in government spending by 1% of output. Under a floating exchange rate regime, trade surplus is caused by exogenous government spending shock whereas trade deficit results from exogenous government spending shock under a fixed exchange rate regime. Those results are consistent with the empirical results, at least qualitatively. What drives those results? As discussed in Monacelli et al. [2010], two different effects determine the sign of net exports in the standard small open economy new Keynesian model: the absorption effect and the switching effect. The former is generated by the response of the monetary authority to inflation. The monetary authority tends to increase nominal interest rate since inflation is boosted by exogenous government spending shock. Intuitively, real interest rate is increasing when nominal interest rate is increasing since the Taylor coefficient is greater than 1 and the Fisher relation holds in the standard model. Suppose all consumers are asset holders ( $\lambda = 0$ ), aggregate consumption decreases since real interest increases, so that imports decline also. As a result, trade balance improves by the absorption

effect.

On the other hand, exogenous government spending shock makes terms-of-trade appreciate, which means that the price of a domestic good to a foreign good becomes expensive and households increase consumption of foreign goods. As a result, trade balance worsens by the switching effect. Monacelli et al. [2010] shows that if the trade price elasticity  $\sigma$  is less than one with the log utility function, the absorption effect dominates the switching effect. However, if  $\sigma$  is greater than one, the opposite result is generated.

In this model, government spending shock crowds out asset holders' consumption and makes terms-of-trade appreciate by the similar procedure described above. Specifically, asset holders' consumption dynamics is determined by the following equation under a floating exchange rate regime similar to Corsetti et al. [2011].

$$c_{A,t} = -\frac{1}{\gamma} \sum_{i=0}^{\infty} (r_{t+i} - \pi_{t+1+i}) = -\frac{1}{\gamma} \sum_{i=0}^{\infty} (\phi_{\pi} \pi_{t+i} - \pi_{t+1+i}) \quad (61)$$

where lower case letters mean percentage deviations from the steady state and the last equality comes from the Taylor rule.<sup>62</sup> This equation shows that asset holders' consumption depends on the current and entire future inflation path. Because of the positive response of inflation (the first panel in the third row in figure 20) and nominal interest rate to government spending shock, consumption of asset holders decreases. The first panel in the second row in figure 19 shows that result. At the same time, government spending shock boosts output, so that disposable income of non-asset holders increases. Therefore consumption of non-asset holders increases as in Gali et al. [2007b]. The second panel in the second row in figure shows increasing in consumption of non-asset holders. However, given the fraction of non-asset

---

<sup>62</sup>The last equality holds only under a floating exchange rate regime. However, the first equality always holds regardless of a nominal exchange rate regime.

holders(1/3), increasing in non-asset holders' consumption is not enough to cover decreasing in asset holder's consumption therefore aggregate consumption decreases (the final panel in the second row in figure 19). As a consequence, trade balance can be improved by the absorption effect.

Furthermore, from the asset holders' optimality condition, the definition of terms-of-trade and real exchange rate, the following equation can be obtained.

$$E_t[\Delta c_{A,t+1}] = -\frac{1}{\gamma}(1 - \omega)E_t[\Delta s_{t+1}] + \frac{1}{\gamma}r_{F,t} \quad (62)$$

Since the world interest rate  $R_t^*$  is assumed to be constant and the debt elasticity ( $\chi$ ) is small,  $r_{F,t}$  is nearly constant and therefore asset holders' consumption is closely related with the response of terms-of-trade. In this model, exogenous government spending shock crowds out asset holder's consumption, so that terms-of-trade appreciates(the third panel in the first row in figure 19). Consequently, trade balance can deteriorate by the switching effect.

Although those two effects are mixed, given the trade price elasticity ( $\sigma < 1$ ), the absorption effect dominates the switching effect due to the similar process discussed in Monacelli et al. [2010] and therefore trade balance improves. Moreover, appreciation of terms-of-trade due to decreasing in asset holders' consumption is also consistent with the empirical results.

On the contrary, the simulation results, especially the response of trade balance, are largely changed under a fixed exchange rate regime. There are two potential channels to alter the results: the UIP channel and the long-run PPP channel. First of all, nominal interest rate is determined by the uncovered interest rate parity (UIP) condition under a fixed exchange rate regime in this model. The monetary authority can adjust nominal interest rate  $R_t$  under a floating exchange rate regime whereas

domestic nominal interest is  $R_t$  fixed at the level of country specific interest rate  $R_{F,t}$  under a fixed exchange rate regime. Because the country specific interest rate ( $R_{F,t}$ ) is almost constant, the domestic nominal interest  $R_t$  is also fixed, which implies monetary policy is more accommodative under a fixed exchange rate regime. By the Fisher relation, increasing in real interest rate is relatively smaller than that under a floating exchange rate regime.<sup>63</sup> Specifically, nominal interest rate is determined by the following UIP condition in this model.

$$r_t - r_{F,t} = -E_t \Delta e_{t+1} \quad (63)$$

Since  $r_{F,t}$  is almost fixed, the monetary authority sets the domestic nominal interest rate  $r_t$  constant to keep change in nominal exchange rate zero. Since increasing in real interest rate is relatively smaller than that under a floating regime, the size of crowding-out is also smaller than that under a floating system by the equation (61).

Contrary to the floating regime case, however, the domestic price level  $P$  should revert back to the original level under a fixed exchange rate regime since nominal exchange rate is fixed and purchasing power parity (PPP) holds in the long run.<sup>64</sup> Thus the domestic inflation should be negative at some points (the first panel in the third row in figure 20), which means that real interest rate should increase. Thus the long-run PPP effect crowds out asset holders' consumption through the relation (61). Although asset holders' consumption is determined by the size of two

---

<sup>63</sup>Born et al. [2013b] show that the short-term real interest rate ( $r_t - \pi_{t+1}$ ) actually declines initially.

<sup>64</sup>Intuitively, each domestic firm increases its price to respond positive government spending initially. However, when the stimulus effect of government spending is weak, each firm down its own price to compete in foreign markets to maximize its profit. Since nominal exchange rate depreciates proportionally over time after positive government spending shock under a floating exchange regime, firms do not need to down their price level. In contrast to the floating case, each firm should down its price level under a fixed regime to compete in foreign markets since nominal exchange rate is fixed. Detailed discussion in Corsetti et al. [2011].



effects, decreasing in asset holders' consumption is smaller than that under a floating exchange rate regime due to the UIP channel (the first panel in the second row in figure 20). Since asset holders' consumption declines less, government spending boosts output more than that under a floating regime and therefore disposable income of non-asset holders increases more. As a result, aggregate consumption can be increasing in contrast to the floating regime case given the fraction  $\lambda$ . By the absorption effect, trade balance deteriorates.

It is worth noting that terms-of-trade still appreciates under a peg system since asset holders' consumption declines and the sign of the response of terms-of-trade is determined by the asset holders' consumption. At qualitative points of view, this model successfully replicates the empirical results.

#### III.4.4 The 1980s Anomaly

In this section, I examine the effects of slow-adjusting taxes on net exports and terms-of-trade to explain the twin deficit in the 1980s. In the 1980s, the Reagan increases government spending largely for the military build-up and reduces tax to boost the economy therefore government debts increase explosively.<sup>65</sup> Huge tax cut stimulates non-asset holders' consumption, thereby aggregate consumption and import can also be stimulated.

First, in order to examine the effect of slow-adjusting taxes, I assume that taxes does not respond to government spending. ( $\psi_{tg} = 0$ ) and compare to the baseline simulation which is the same in section III.4.3 with a floating regime. Small  $\psi_{tg}$  means that taxes are less sensitive to increasing in government spending, which can be interpreted as slow-adjusting taxes.

To compare with the baseline and the slow-adjusting taxes case, non-asset hold-

---

<sup>65</sup>Detailed discussions of tax and budget policy in 1980s are provided in Feldstein [1994].

ers' consumption (the second panel in the second row in figure 21) is larger in the slow-adjusting taxes case than that in the baseline case. Because of slow-adjusting taxes, disposable income is increasing more through non-asset holders' budget constraint, which drives increasing in hand-to-mouth consumers' consumption. At the same time, asset holders' consumption is lower in the slow-adjusting taxes case than that in the baseline case since asset holders expect the heavier tax burden in future. The government should issue bonds more with the slow tax adjustment by the government budget constraint thus the future tax burden of asset holders is increasing and therefore negative wealth effect becomes more stronger. The stronger negative wealth effects crowd out asset holders' consumption more.

Though two effects are mixed, given parameters, trade balance deteriorates more by the absorption effect with the slow-adjusting taxes than that in the baseline case, but the size of trade deficit is small (the second panel in the first row in figure 20). However, if the fraction of non-asset holder ( $\lambda$ ) increases for some reasons,<sup>66</sup> the slow tax adjustment process boosts aggregate consumption of non-asset holders more as in Gali et al. [2007b], which drives larger trade deficit. Moreover, terms-of-trade appreciates in response to government spending shock (the third panel in the first row in figure 20) because of decline in asset holders' consumption in both low and high  $\lambda$  case.

To summarize, government spending shock with slow-adjusting taxes stimulates hand-to-mouth consumers' consumption and also import more than that without slow adjustment, which possibly makes trade deficit even with a floating exchange rate regime, albeit the size of trade deficit is sensitive to the fraction of hand-to-

---

<sup>66</sup>For example, the US economy experienced severe recessions in early 1980s. Garcia et al. [1997] and Fissel and Jappelli [1990] show that the fraction of liquidity constraint consumers tend to increase in recessions. Moreover, Gali et al. [2007b] estimate  $\lambda$  close to 0.5 with 1954 to 2004 US data. Campbell and Mankiw [1989] also report that  $\lambda$  is close to 0.5. Bilbiie et al. [2008] estimate  $\lambda$  close to 0.5 with 1957 to 1979 US data.

mouth consumer.

### III.5 Concluding Remarks

This paper examines effects of structural changes on the relation between government budget balances and external balances. Through a time-varying structural VAR model and the post WWII data for the US economy, the following four empirical results are obtained: (1) In the Bretton Woods era, increasing in government spending leads trade deficits. (2) Opposite to the Bretton Woods era, increasing in government spending induces trade surplus in the post-Bretton Woods era. (3) Anomaly in the 1980s: Trade deficits are caused by a government spending shock in 1980s in spite of adopting a floating exchange regime in the US. (4) The response of terms-of-trade is stable across the periods: Appreciation (increasing in value of real dollar) after initial small depreciation. To provide some insights about empirical results, I construct a small open economy New Keynesian model incorporated rule-of-thumb consumers suggested by Gali et al. [2007b]. An exchange rate regime change and rule-of-thumb consumers may be useful to understand the results (1) and (2). Slow-adjusting taxes may be useful to understand the result (3).

## CHAPTER IV

## CONCLUSION

This dissertation studies the effects of fiscal policy on the economy at the macroeconomic level using various empirical models and the New Keynesian perspective.

In Chapter II, I focus on the state-dependent effects of government debt on government spending multipliers using state-dependent impulse responses drawn by the two-states local projection method, US historical data, and a government spending shock identified by the defense news variable constructed by Ramey [2012], and updated by Owyang et al. [2013]. For the estimation, a new quarterly historical US government debt data from 1890.Q1 to 2010.Q4 is constructed. The empirical results reveal that the spending multipliers in a high debt state are larger than those in a low debt state, at least, in short-run, which is contrary to the conventional prediction. To provide a possible channel to understand the result, I construct a simple New Keynesian model. The simple model suggests that spending reversals and the interaction between those spending reversals and monetary policy in a high debt state could be a potential channel to understand the large short-run multipliers in a high debt state. The empirical and theoretical results may imply that the short-run stimulus effects of government spending depends not only on current spending but also on future spending plans. Thus, it is important to manage households' expectation of future spending plans for the performance of a fiscal stimulus package as well as fiscal consolidation.

In Chapter III, I examine effects of structural changes on the relation between government budget balances and external balances. Through a time-varying structural VAR model and the post WWII data for the US economy, the following four

empirical results are obtained: (1) In the Bretton Woods era, increasing in government spending leads trade deficits. (2) Opposite to the Bretton Woods era, increasing in government spending induces trade surplus in the post-Bretton Woods era. (3) Anomaly in the 1980s: Trade deficits are caused by a government spending shock in 1980s in spite of adopting a floating exchange regime in the US. (4) The response of terms-of-trade is stable across the periods: Appreciation (increasing in value of real dollar) after initial small depreciation. To provide some insights about empirical results, I construct a small open economy New Keynesian model incorporated rule-of-thumb consumers suggested by Gali et al. [2007b]. An exchange rate regime change and rule-of-thumb consumers may be useful to understand the results (1) and (2). Slow-adjusting taxes may be useful to understand the result (3).

This dissertation could be extended in several directions. For Chapter II, it is important to construct other historical macroeconomic data and to investigate transmission channels of government spending. Particularly, the simple theory suggests that the responses of consumption and real interest rate may significantly differ by the level of debt. Thus it is worth constructing historical household consumption and real interest data and investigating how responses of those variables to a spending shock depend on the level of debt. For Chapter II, a rigorous theoretical model to explain the empirical results is worth developing. Although the theoretical model that I construct provides a potential channel to understand the empirical results, the model omits several important dimensions such as investment dynamics, and other frictions. Moreover, it could be important to introduce nominal interest rate zero lower bound and to study the interaction between nonlinear fiscal policy and monetary policy at the zero lower bound.

## REFERENCES

- António Afonso and Ricardo M Sousa. The macroeconomic effects of fiscal policy. *Applied Economics*, 44(34):4439–4454, 2012.
- Alberto Alesina and Roberto Perotti. Fiscal expansions and fiscal adjustments in oecd countries. Working Paper 5214, National Bureau of Economic Research, August 1995.
- Alberto F. Alesina and Silvia Ardagna. Large changes in fiscal policy: Taxes versus spending. Working Paper 15438, National Bureau of Economic Research, October 2009.
- Philip Arestis, Andrea Cipollini, and Bassam Fattouh. Threshold effects in the US budget deficit. *Economic Inquiry*, 42(2):214–222, 2004.
- Alan J Auerbach. Formation of fiscal policy: the experience of the past twenty-five years. *Federal Reserve Bank of New York Economic Policy Review*, 6(1):9–23, 2000.
- Alan J. Auerbach and Yuriy Gorodnichenko. Fiscal multipliers in recession and expansion. Working Paper 17447, National Bureau of Economic Research, September 2011.
- Alan J. Auerbach and Yuriy Gorodnichenko. Measuring the Output Responses to Fiscal Policy. *American Economic Journal: Economic Policy*, 4(2):1–27, May 2012.

- David K Backus and Gregor W Smith. Consumption and real exchange rates in dynamic economies with non-traded goods. *Journal of International Economics*, 35(3):297–316, 1993.
- Robert J Barro and Charles J Redlick. Macroeconomic effects from government purchases and taxes. *The Quarterly Journal of Economics*, 126(1):51–102, 2011.
- Anja Baum, Marcos Poplawski-Ribeiro, and Anke Weber. Fiscal multipliers and the state of the economy. IMF Working Papers 12/286, International Monetary Fund, December 2012.
- Christiane Baumeister and Gert Peersman. Time-varying effects of oil supply shocks on the US economy. *American Economic Journal: Macroeconomics*, 5(4):1–28, 2013.
- Roel Beetsma, Massimo Giuliodori, and Franc Klaassen. The effects of public spending shocks on trade balances and budget deficits in the European Union. *Journal of the European Economic Association*, 6(2-3):414–423, 2008.
- Roel Maria Wilhelmus Jozef Beetsma, Massimo Giuliodori, and Franc Klaassen. Temporal aggregation and SVAR identification, with an application to fiscal policy. *Economics Letters*, 105(3):253–255, 2009.
- Luca Benati and Haroon Mumtaz. U.S. evolving macroeconomic dynamics: a structural investigation. Working Paper Series 0746, European Central Bank, April 2007.
- Giuseppe Bertola and Allan Drazen. Trigger points and budget cuts: Explaining the effects of fiscal austerity. *The American Economic Review*, pages 11–26, 1993.

- Huixin Bi. Sovereign default risk premia, fiscal limits, and fiscal policy. *European Economic Review*, 56(3):389–410, 2012.
- Florin O Bilbiie, André Meier, and Gernot J Müller. What accounts for the changes in US fiscal policy transmission? *Journal of Money, Credit and Banking*, 40(7):1439–1470, 2008.
- Olivier Blanchard and Roberto Perotti. An empirical characterization of the dynamic effects of changes in government spending and taxes on output. *The Quarterly Journal of economics*, 117(4):1329–1368, 2002.
- Henning Bohn. Budget balance through revenue or spending adjustments?: Some historical evidence for the united states. *Journal of monetary economics*, 27(3):333–359, 1991.
- Henning Bohn. The behavior of US public debt and deficits. *The Quarterly Journal of economics*, 113(3):949–963, 1998.
- Benjamin Born and Gernot J Müller. Government spending shocks in quarterly and annual time series. *Journal of Money, Credit and Banking*, 44(2-3):507–517, 2012.
- Benjamin Born, Falko Juessen, and Gernot J. Müller. Exchange rate regimes and fiscal multipliers. *Journal of Economic Dynamics and Control*, 37(2):446 – 465, 2013a.
- Benjamin Born, Falko Juessen, and Gernot J. Müller. Exchange rate regimes and fiscal multipliers. *Journal of Economic Dynamics and Control*, 37(2):446 – 465, 2013b.
- William H Branson, Herbert Giersch, and Peter G Peterson. Trends in United States



- international trade and investment since World War II. In *The American economy in transition*, pages 183–274. University of Chicago Press, 1980.
- John Y Campbell and N Gregory Mankiw. Consumption, income and interest rates: Reinterpreting the time series evidence. In *NBER Macroeconomics Annual 1989, Volume 4*, pages 185–246. MIT Press, 1989.
- Fabio Canova and Matteo Ciccarelli. Estimating multi-country VAR models. *International Economic Review*, 50(3):929–959, 2009.
- Fabio Canova and Luca Gambetti. Structural changes in the US economy: Is there a role for monetary policy? *Journal of Economic Dynamics and Control*, 33(2):477–490, 2009.
- Chris K Carter and Robert Kohn. On gibbs sampling for state space models. *Biometrika*, 81(3):541–553, 1994.
- Brian W Cashell. The federal government debt: Its size and economic significance. *CRS Report for Congress*, 2010.
- Cristina Checherita-Westphal and Philipp Rother. The impact of high government debt on economic growth and its channels: An empirical investigation for the euro area. *European Economic Review*, 56(7):1392–1405, 2012.
- Menzie D Chinn and Eswar S Prasad. Medium-term determinants of current accounts in industrial and developing countries: an empirical exploration. *Journal of International Economics*, 59(1):47–76, 2003.
- Hess Chung and Eric M. Leeper. What has financed government debt? Working Paper 13425, National Bureau of Economic Research, September 2007.

- Jacopo Cimadomo, Sebastian Hauptmeier, and Sergio Sola. Identifying the effects of government spending shocks with and without expected reversal: an approach based on U.S. real-time data. Working Paper Series 1361, European Central Bank, July 2011.
- Andrea Cipollini, Bassam Fattouh, and Kostas Mouratidis. Fiscal readjustments in the united states: A nonlinear time-series analysis. *Economic Inquiry*, 47(1): 34–54, 2009.
- Timothy Cogley and Thomas J Sargent. Drifts and volatilities: monetary policies and outcomes in the post WWII US. *Review of Economic dynamics*, 8(2):262–302, 2005.
- Giancarlo Corsetti and Gernot J Müller. Twin deficits: squaring theory, evidence and common sense. *Economic Policy*, 21(48):597–638, 2006.
- Giancarlo Corsetti, Andre Meier, and Gernot J Müller. Fiscal stimulus with spending reversals. CEPR Discussion Papers 7302, 2009.
- Giancarlo Corsetti, Keith Kuester, and Gernot J Müller. Floats, pegs and the transmission of fiscal policy. CEPR Discussion Papers 8180, January 2011.
- Giancarlo Corsetti, André Meier, and Gernot J Müller. Fiscal stimulus with spending reversals. *Review of Economics and Statistics*, 94(4):878–895, 2012a.
- Giancarlo Corsetti, Andre Meier, and Gernot J Müller. What determines government spending multipliers? *Economic Policy*, 27(72):521–565, 2012b.
- Giancarlo Corsetti, Keith Kuester, André Meier, and Gernot J Müller. Sovereign risk, fiscal policy, and macroeconomic stability. *The Economic Journal*, 123(566): F99–F132, 2013.

- Zeno Enders, Gernot J Müller, and Almuth Scholl. How do fiscal and technology shocks affect real exchange rates?: New evidence for the united states. *Journal of International Economics*, 83(1):53–69, 2011.
- Christopher J Erceg, Luca Guerrieri, and Christopher Gust. Expansionary fiscal shocks and the US trade deficit. *International Finance*, 8(3):363–397, 2005.
- Antonio Fatás and Ilian Mihov. The effects of fiscal policy on consumption and employment: Theory and evidence. CEPR Discussion Papers 2760, April 2001.
- Carlo Favero and Francesco Giavazzi. Debt and the effects of fiscal policy. Working Paper 12822, National Bureau of Economic Research, January 2007.
- Steven Mark Fazzari, James Morley, and Irina Panovska. State-dependent effects of fiscal policy. Discussion Papers 2012-27A, School of Economics, The University of New South Wales, 2013.
- Martin Feldstein. *American Economic Policy in the 1980s*. University of Chicago Press, 1994.
- Jonas DM Fisher and Ryan Peters. Using stock returns to identify government spending shocks. *The Economic Journal*, 120(544):414–436, 2010.
- Gary S Fissel and Tullio Jappelli. Do liquidity constraints vary over time? evidence from survey and panel data: Note. *Journal of Money, Credit and Banking*, 22(2): 253–262, 1990.
- Lorenzo Forni and Massimiliano Pisani. Fiscal policy in an open economy: estimates for the euro area. Working paper, Bank of Italy, 2010.
- Jordi Gali and Tommaso Monacelli. Monetary policy and exchange rate volatility in a small open economy. *The Review of Economic Studies*, 72(3):707–734, 2005.

- Jordi Galí and Roberto Perotti. Fiscal policy and monetary integration in Europe. *economic policy*, 18(37):533–572, 2003.
- Jordi Gali, J David López-Salido, and Javier Vallés. Understanding the effects of government spending on consumption. *Journal of the European Economic Association*, 5(1):227–270, 2007a.
- Jordi Gali, J David López-Salido, and Javier Vallés. Understanding the effects of government spending on consumption. *Journal of the European Economic Association*, 5(1):227–270, 2007b.
- René Garcia, Annamaria Lusardi, and Serena Ng. Excess sensitivity and asymmetries in consumption: An empirical investigation. *Journal of Money, Credit and Banking*, 29(2):154–76, 1997.
- Mark Gertler, Simon Gilchrist, and Fabio M Natalucci. External constraints on monetary policy and the financial accelerator. *Journal of Money, Credit and Banking*, 39(2-3):295–330, 2007.
- Joseph W Gruber and Steven B Kamin. Explaining the global pattern of current account imbalances. *Journal of International Money and Finance*, 26(4):500–522, 2007.
- Robert E. Hall. By how much does gdp rise if the government buys more output? Working Paper 15496, National Bureau of Economic Research, November 2009.
- Abdulnasser Hatemi-j and Ghazi Shukur. Multivariate-based causality tests of twin deficits in the us. *Journal of Applied Statistics*, 29(6):817–824, 2002.
- Shafik Hebous. The effects of discretionary fiscal policy on macroeconomic aggregates: a reappraisal. *Journal of Economic Surveys*, 25(4):674–707, 2011.

- Burkhard Heer and Alfred Maussner. *Dynamic general equilibrium modeling: computational methods and applications*. Springer, 2009.
- Pablo Hernández de Cos and Enrique Moral-Benito. Fiscal multipliers in turbulent times: the case of Spain. Banco de Espana Working Papers 1309, Banco de Espana, June 2013.
- Ethan Ilzetzki, Enrique G Mendoza, and Carlos A Végh Gramont. How big (small?) are fiscal multipliers? *Journal of monetary economics*, 60(2):239–254, 2013.
- Óscar Jordá. Estimation and inference of impulse responses by local projections. *The American Economic Review*, 95(1):pp. 161–182, 2005.
- Sangjoon Kim, Neil Shephard, and Siddhartha Chib. Stochastic volatility: likelihood inference and comparison with ARCH models. *The Review of Economic Studies*, 65(3):361–393, 1998.
- Soyoung Kim and Nouriel Roubini. Twin deficit or twin divergence? fiscal policy, current account, and real exchange rate in the US. *Journal of International Economics*, 74(2):362–383, 2008.
- Wongi Kim. Do government spending multipliers depend on the level of government debt? us historical data evidence. *Applied Economics Letters*, 22(8):668–672, 2015.
- Markus Kirchner, Jacopo Cimadomo, and Sebastian Hauptmeier. Transmission of government spending shocks in the euro area: Time variation and driving forces. Working Paper Series 1219, European Central Bank, July 2010.
- Robert Kollmann. Monetary policy rules in the open economy: effects on welfare and business cycles. *Journal of Monetary Economics*, 49(5):989–1015, 2002.

- Gary Koop, Roberto Leon-Gonzalez, and Rodney W Strachan. On the evolution of the monetary policy transmission mechanism. *Journal of Economic Dynamics and Control*, 33(4):997–1017, 2009.
- Lori L Leachman and Bill Francis. Twin deficits: apparition or reality? *Applied Economics*, 34(9):1121–1132, 2002.
- Eric M Leeper, Michael Plante, and Nora Traum. Dynamics of fiscal financing in the united states. *Journal of Econometrics*, 156(2):304–321, 2010.
- Eric M Leeper, Todd B Walker, and Shu-Chun Susan Yang. Fiscal foresight and information flows. *Econometrica*, 81(3):1115–1145, 2013.
- Catherine L Mann. Perspectives on the us current account deficit and sustainability. *The Journal of Economic Perspectives*, 16(3):131–152, 2002.
- Karel Mertens. Marginal tax rates and income: New time series evidence. Working Paper 19171, National Bureau of Economic Research, June 2013.
- Karel Mertens and Morten O Ravn. Measuring the impact of fiscal policy in the face of anticipation: A structural VAR approach. *The Economic Journal*, 120(544):393–413, 2010.
- Pascal Michaillat. A theory of countercyclical government multiplier. *American economic journal: macroeconomics*, 6(1):190–217, 2014.
- Tommaso Monacelli and Roberto Perotti. Openness and the sectoral effects of fiscal policy. *Journal of the European Economic Association*, 6(2-3):395–403, 2008.
- Tommaso Monacelli, Roberto Perotti, and Antonella Trigari. Unemployment fiscal multipliers. *Journal of Monetary Economics*, 57(5):531 – 553, 2010.

- Andrew Mountford and Harald Uhlig. What are the effects of fiscal policy shocks? *Journal of applied econometrics*, 24(6):960–992, 2009.
- Gernot J Müller. Understanding the dynamic effects of government spending on foreign trade. *Journal of International Money and Finance*, 27(3):345–371, 2008.
- Michael T Owyang, Valerie A Ramey, and Sarah Zubairy. Are government spending multipliers greater during periods of slack? Evidence from twentieth-century historical data. *American Economic Review*, 103(3):129–34, 2013.
- Manuel Coutinho Pereira and Artur Silva Lopes. Time-varying fiscal policy in the US. Working Papers Series w201021, Banco de Portugal, 2010.
- Roberto Perotti. Fiscal policy in good times and bad. *The Quarterly Journal of Economics*, 114(4):1399–1436, 1999.
- Roberto Perotti. Estimating the effects of fiscal policy in OECD countries. *IGIER Working Paper No. 276*, 2004.
- Roberto Perotti. Expectations and fiscal policy: An empirical investigation. *IGIER Working Paper No. 429*, 2011.
- Alessandro Piergallini and Michele Postigliola. Non-linear budgetary policies: Evidence from 150 years of Italian public finance. *Economics Letters*, 121(3):495–498, 2013.
- Giorgio E Primiceri. Time varying structural vector autoregressions and monetary policy. *The Review of Economic Studies*, 72(3):821–852, 2005.
- Sohrab Rafiq. Fiscal stance, the current account and the real exchange rate: Some empirical estimates from a time-varying framework. *Structural Change and Economic Dynamics*, 21(4):276–290, 2010.

- Sohrab Rafiq. Is discretionary fiscal policy in Japan effective? *The BE Journal of Macroeconomics*, 12(1), 2012.
- Valerie Ramey. “Comment on roads to prosperity or bridges to nowhere? Theory and evidence on the impact of public infrastructure investment”. In *NBER Macroeconomics Annual 2012, Volume 27*, NBER Chapters, pages 147–153. National Bureau of Economic Research, Inc, 2012.
- Valerie A Ramey. Identifying government spending shocks: It’s all in the timing. *The Quarterly Journal of Economics*, 126(1):1–50, 2011a.
- Valerie A Ramey. Can government purchases stimulate the economy? *Journal of Economic Literature*, 49(3):673–685, 2011b.
- Valerie A Ramey and Matthew D Shapiro. Costly capital reallocation and the effects of government spending. In *Carnegie-Rochester Conference Series on Public Policy*, volume 48, pages 145–194. Elsevier, 1998.
- Valerie A. Ramey and Sarah Zubairy. Government spending multipliers in good times and in bad: Evidence from U.S. historical data. Working paper, 2014.
- Morten O. Ravn, Stephanie Schmitt-Grohé, and Martín Uribe. Explaining the effects of government spending shocks on consumption and the real exchange rate. Working Paper 13328, National Bureau of Economic Research, August 2007.
- Christopher Phillip Reicher. An estimated fiscal Taylor Rule for the postwar United States. *Economics Letters*, 114(3):319–321, 2012.
- Carmen M Reinhart and Kenneth S Rogoff. Growth in a time of debt. *The American Economic Review*, 100(2):573–78, 2010.



- Nouriel Roubini. Current account and budget deficits in an intertemporal model of consumption and taxation smoothing. A solution to the “Feldstein-Horioka puzzle”? Working Paper 2773, National Bureau of Economic Research, November 1988.
- Lucio Sarno. The behavior of us public debt: a nonlinear perspective. *Economics Letters*, 74(1):119–125, 2001.
- Stephanie Schmitt-Grohé and Martin Uribe. Closing small open economy models. *Journal of international Economics*, 61(1):163–185, 2003.
- Robert J Shiller. *Irrational exuberance*. Random House Digital, Inc., 2005.
- Douglas Staiger and James H Stock. Instrumental variables regression with weak instruments. *Econometrica*, 65(3):557–586, 1997.
- James H Stock. Evolving post-World War II US inflation dynamics: Comment. *NBER macroeconomics annual*, 16:379–387, 2001.
- James H Stock and Mark W Watson. Disentangling the channels of the 2007–09 recession. *Brookings Papers on Economic Activity*, 2012(1):81–135, 2012.
- Alan Sutherland. Fiscal crises and aggregate demand: can high public debt reverse the effects of fiscal policy? *Journal of Public Economics*, 65(2):147–162, 1997.
- John B Taylor. *Macroeconomic policy in a world economy: from econometric design to practical operation*. WW Norton New York, 1993.
- Michael Woodford. Simple analytics of the government expenditure multiplier. *American Economic Journal: Macroeconomics*, 3(1):1–35, 2011.

Sarah Zubairy. On fiscal multipliers: Estimates from a medium scale DSGE model.  
*International Economic Review*, 55(1):169–195, 2014.

## APPENDIX A

### DETAILS OF GIBBS SAMPLING

In this paper, the TVP-VAR model is estimated with Bayesian Markov chain Monte Carlo(MCMC) techniques proposed by Cogley and Sargent [2005], Primiceri [2005] and Canova and Ciccarelli [2009]. The procedures are mainly based on Primiceri [2005] with minor modifications proposed by Canova and Ciccarelli [2009] for the calibration of the priors. It is convenient to define two notations.

$$x^\tau = [x'_1, \dots, x'_\tau]', \quad M^\tau = [m'_1, \dots, m'_\tau]'$$

The former one denotes a generic vector of variables  $x$  up to a time  $\tau$ . The later denotes a generic matrix  $M$  with its column vector  $m$  constructed by the time varying components of  $M$  up to time  $\tau$ . Gibbs sampling is conducted with the following four steps.

Step 1: Drawing coefficient states  $B^T$ . Conditional on the data and  $A^T, \Sigma^T$  and  $V$ , the measurement equation (26) is a standard linear-Gaussian model with known variance. As shown in Carter and Kohn [1994], the density  $P(B^T|y^T, A^T, \Sigma^T, V)$  can be factored as

$$p(B^T|y^T, A^T, \Sigma^T, V) = p(B_T|y^T, A^T, \Sigma^T, V) \prod_{t=1}^{T-1} p(B_t|B_{t+1}, y^t, A^T, \Sigma^T, V) \quad (64)$$

where

$$B_t | B_{t+1}, y^t, A^T, \Sigma^T, V \sim N(B_{t|t+1}, P_{t|t+1}) \quad (65)$$

$$B_T | y^T, A^T, \Sigma^T, V \sim N(B_{T|T}, P_{T|T}) \quad (66)$$

$$B_{t|t+1} = E[B_t|B_{t+1}, y^t, A^T, \Sigma^T, V] \quad (67)$$

$$P_{t|t+1} = Var(B_t|B_{t+1}, y^t, A^T, \Sigma^T, V) \quad (68)$$

$p$  denotes a density function,  $N$  is the normal distribution and  $E$  is the expectation operator. Since the measurement equation (26) and the state equation (27) has a standard linear-Gaussian form, the standard Kalman filter and the backward recursion can be applied to draw coefficient states similar in Primiceri [2005]. Specifically, the forward Kalman filter delivers  $B_{T|T}$  and  $P_{T|T}$  which is mean and variance of the posterior of  $B_T$  as its last recursion point. The first point of backward recursion is drawn from  $N(B_{T|T}, P_{T|T})$ . Furthermore, using  $B_{T|T}$ ,  $P_{T|T}$  and the backward recursion, the remaining can be drawn from  $N(B_{t|t+1}, P_{t|t+1})$ ,  $t = 1, \dots, T - 1$ .

Step 2: Drawing covariance states  $A^T$ . The measurement equation (26) can be rewritten as

$$A_t(y_t - X_t' B_t) = A_t \hat{y}_t = \Sigma_t \varepsilon_t \quad (69)$$

Note that conditional on  $B^T$ ,  $\hat{y}_t$  can be observable. Because  $A_t$  has a particular form(lower triangular with ones on the main diagonal), the equation (69) can be written as follows:

$$\hat{y}_t = Z_t \alpha_t + \Sigma_t \varepsilon_t \quad (70)$$

where  $Z_t$  is an  $n \times \frac{n(n+1)}{2}$  matrix given by

$$Z_t = \begin{bmatrix} 0 & \cdots & \cdots & 0 \\ -\hat{y}_{1,t} & 0 & \cdots & 0 \\ 0 & (-\hat{y}_{1,t}, -\hat{y}_{2,t}) & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & (-\hat{y}_{1,t}, \dots, -\hat{y}_{n,t}) \end{bmatrix} \quad (71)$$

Unfortunately, the standard Kalman filter and the backward recursion cannot be applied since the system is Gaussian but non-linear since the dependent variable in the measurement equation appears on the  $Z_t$  in general cases. However, Primiceri [2005] shows that the system becomes linear under the block diagonal assumption of  $S$ . Under the assumption of  $S$ , therefore, the same procedure in appendix B.1 allows to recover  $\alpha_t$  and associated variance  $\Lambda_t$  by

$$\alpha_{i,t|t+1} = E[\alpha_{i,t} | \alpha_{i,t+1}, y^t, B^T, \Sigma^T, V] \quad (72)$$

$$\Lambda_{i,t|t+1} = Var(\alpha_{i,t} | \alpha_{i,t+1}, y^t, B^T, \Sigma^T, V) \quad (73)$$

$$\alpha_{i,t} | \alpha_{i,t+1}, y^t, B^T, \Sigma^T, V \sim N(\alpha_{i,t|i,t+1}, \Lambda_{i,t|i,t+1}) \quad (74)$$

where  $\alpha_{i,t}$  is the  $i$ -th block of  $\alpha_t$  and  $\Lambda_{i,t}$  is associated variance.<sup>67</sup>

Step 3: Drawing volatility states  $\Sigma^T$ . Conditional on  $B^T$ ,  $A^T$ ,  $V$  and data, the measurement equation (26) can be rewritten as

$$A_t(y_t - X_t' B_t) = y_t^* = \Sigma_t \varepsilon_t \quad (75)$$

where  $y_t^*$  can be observable conditional on  $B^T$  and  $A^T$ . This system itself is non-linear but taking squaring and logarithm of every elements in the equation, the following linear equation system is derived.

$$y_t^{**} = 2h_t + e_t \quad (76)$$

$$h_t = h_{t-1} + \eta_t \quad (77)$$

---

<sup>67</sup>Without block diagonal assumption, minor modifications for the procedures are needed. Detailed discussions are available in Appendix D in Primiceri [2005]

where  $y_{i,t}^{**} = \log((y_{i,t}^*)^2 + c^*)$ ,  $e_{i,t} = \log(\varepsilon_{i,t}^2)$ ,  $h_{i,t} = \log \sigma_{i,t}$  and  $i = 1, \dots, n$ .<sup>68</sup> Since  $\varepsilon$ 's and  $\eta$ 's are assumed to be independent,  $e$ 's and  $\eta$ 's are not correlated. The transformed systems is linear but it is a non-Gaussian because  $e$ 's are distributed as a  $\log \chi^2$ . Fortunately, this linear but non-Gaussian model can be approximated to a linear-Gaussian state space form with mixture normal density by the method proposed by Kim et al. [1998]. The mixture density is given by

$$p(e_{i,t}) \approx \sum_{j=1}^7 q_j p_N(e_{i,t}; m_j - 1.2704, v_j^2) \quad (78)$$

where  $q_j$  is probability,  $m_j$  is mean,  $v_j^2$  is variance,  $p_N$  is a normal density function.  $q_j$ ,  $m_j$  and  $v_j^2$  are known constants chosen to match a number of moments of the  $\log \chi^2(1)$ . In appendix A, the choice of  $q_j$ ,  $m_j$  and  $v_j^2$  is reported. Conditioning on the realization of an random indicator variable  $s_{i,t}$ , one element of the mixture normal density is selected. In other words,

$$e_{i,t} | s_{i,t} = j \sim N(m_j - 1.2704, v_j^2), \quad i = 1, \dots, n \quad j = 1, \dots, 7 \quad (79)$$

The standard Kalman filter and the backward recursion can be applied the approximated linear-Gaussian system to draw  $h_t$  given a selection of  $s^T = [s_1, \dots, s_T]'$ ,  $B^T$ ,  $A^T$  and  $V$  as in appendix A.

Note that as in Kim et al. [1998], the random indicator variable  $s_{i,t}$  can be drawn conditional on a history of  $y_{i,t}^{**}$  and the new  $h_{i,t}$  using the following density.

$$Pr(s_{i,t} = j | y_{i,t}^{**}, h_{i,t}) \propto q_j p_N(y_{i,t}^{**} | 2h_{i,t} + m_j - 1.2704, v_j^2), \quad i = 1, \dots, n \quad j = 1, \dots, 7 \quad (80)$$

---

<sup>68</sup> $c^*$  is the offset constant which is set to be 0.001 following Primiceri [2005]. This constant is introduced in order to robustify the estimation procedure to  $y_t^{**}$  being very small. See Kim et al. [1998]

Step 4: Drawing hyperparameters  $V$ . The hyperparameters in this model are the diagonal blocks of variance matrix  $V$ :  $Q$ (coefficient states),  $W$ (volatility states) and the block diagonal of  $S$ (covariance states). Taking  $B^T$ ,  $A^T$ ,  $\Sigma^T$  and  $y^T$  as given, all innovations are observable. Since all innovations are assumed to be independent to each others, each square block has an inverse-Wishart posterior distribution and is easily drawn from these inverse-Wishart posterior given the proper priors.

Gibbs sampling for state space models A measurement equation is given by

$$y_t = H_t \beta_t + \varepsilon_t \quad (81)$$

and state equation is

$$\beta_t = F \beta_{t-1} + u_t \quad (82)$$

where

$$\begin{bmatrix} \varepsilon_t \\ u_t \end{bmatrix} \sim \text{i.i.d } N \left( \begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} R_t & 0 \\ 0 & Q \end{bmatrix} \right) \quad (83)$$

Let

$$\beta_{t|s} = E[\beta_t | Y^s, H^s, R^s, Q] \quad (84)$$

$$V_{t|s} = \text{Var}(\beta_t | Y^s, H^s, R^s, Q) \quad (85)$$

Given initial  $\beta_{0|0}$  and  $V_{0|0}$ , the standard Kalman filter gives:

$$\beta_{t|t-1} = F \beta_{t-1|t-1} \quad (86)$$

$$V_{t|t-1} = F V_{t-1|t-1} F' + Q \quad (87)$$

$$\beta_{t|t} = \beta_{t|t-1} + V_{t|t-1} H_t' (H_t V_{t|t-1} H_t' + R_t)^{-1} (y_t - H_t \beta_{t|t-1}) \quad (88)$$

$$V_{t|t} = V_{t|t-1} - V_{t|t-1}H_t'(H_tV_{t|t-1}H_t' + R_t)^{-1}H_tV_{t|t-1} \quad (89)$$

Note that  $V_{t|t-1}H_t'(H_tV_{t|t-1}H_t' + R_t)^{-1}$  is the Kalman gain. The last recursion elements  $\beta_{T|T}$  and  $V_{T|T}$  are the mean and the variance of the posterior of  $\beta_{T|T}$ . With factored density of  $\beta^T$  and the backward recursion,  $\beta_{T-1}$  can be obtained. This procedures continues until time zero given updating equations of the backward recursion:

$$\beta_{t|t+1} = \beta_{t|t} + V_{t|t}F'V_{t+1|t}^{-1}(\beta_{t+1} - F\beta_{t|t}) \quad (90)$$

$$V_{t|t+1} = V_{t|t} - V_{t|t}F'V_{t+1|t}^{-1}FV_{t|t} \quad (91)$$

Selection of the mixing distribution to be  $\log \chi^2(1)$  is as follows.

$\omega$	$q_j = Pr(\omega = j)$	$m_j$	$v_j^2$
1	0.00730	-10.12999	5.79596
2	0.10556	-3.97281	2.61369
3	0.00002	-8356686	5.1795
4	0.04395	2.77786	0.16735
5	0.34001	0.61942	0.64009
6	0.24566	1.79518	0.34023
7	0.2575	-1.08819	1.26261

Source:Kim et al. [1998]

Calibration of the priors is as follows In most TVP-VAR studies, priors are calibrated with OLS estimators from an initial “trained data” which is then discarded. As opposed to most previous TVP-VAR studies, I use full sample OLS estimators to calibrate the priors following Canova and Ciccarelli [2009] for two reasons.<sup>69</sup> First, I do not want to sacrifice some initial data points. With the trained data method, some initial data points of Brettonwoods system should be discarded, which possibly

<sup>69</sup>In Kirchner et al. [2010] and Rafiq [2012], they also use full sample OLS estimators to calibrate their priors.



misguided the effects of nominal exchange regime. Secondly, this methods minimize the uncertain involved in calibrating the priors properly as described in Canova and Ciccarelli [2009].

VAR coefficients are as follows Let  $B_{OLS}$  be the OLS estimator from the full-sample time invariant VAR and  $\Xi_B$  is its variance-covariance matrix. Following Primiceri [2005],  $B_0$  the prior for  $B$  are assumed to be

$$B_0 \sim N(B_{OLS}, 4 \times \Xi_B) \quad (92)$$

Covariance states are as follows Let  $A_{OLS}$  be the Cholesky components(lower triangular matrix) in the time invariant VAR and  $\Xi_A$  be its variance-covariance matrix. The prior of covariance states of the model is assumed to be

$$A_0 \sim N(A_{OLS}, 4 \times \Xi_A) \quad (93)$$

This specification is the same one in Primiceri [2005]

Volatility states are as follows Let  $\log \sigma_0$  be the OLS estimators of variance matrix(diagonal matrix of Cholesky decomposition) in time invariant VAR. The prior for volatility states is assumed to be

$$\log \sigma_0 \sim N(\log \sigma_{OLS}, I_n) \quad (94)$$

which is similar to the one in Primiceri [2005] and Canova and Gambetti [2009].

Hyperparameters are as follows The prior for  $Q$ , the variance-covariance matrix for  $B_t$ , is set to be

$$Q \sim IW(\kappa_Q^2 \times (dim(B_{OLS}) + 1) \times \Xi_B, dim(B_{OLS}) + 1) \quad (95)$$

Following Primiceri [2005], I set  $\kappa_Q = 0.01$ .  $\dim(B_{OLS}) + 1$  is set to be the degree of freedom of the inverse-wishart prior. The degree of freedom which I choose is widely used in time varying parameter VAR literatures such as Benati and Mumtaz [2007], Kirchner et al. [2010], Pereira and Lopes [2010] and Rafiq [2012]. Also,  $\dim(B_{OLS}) + 1$  is the minimum number of degrees of freedom for the appropriate priors.<sup>70</sup>

The prior of  $W$ , the variance-covariance matrix for the innovations of  $\log \sigma_t$ , is assumed to be

$$W \sim IW(\kappa_W^2 \times (\dim(\sigma_{OLS}) + 1) \times I_n, \dim(\sigma_{OLS}) + 1) \quad (96)$$

Following Primiceri [2005],  $\kappa_Q = 0.1$ . Following Benati and Mumtaz [2007], I set the degree of freedom of inverse-wishart to  $\dim(\sigma_{OLS}) + 1$  which is the minimum degree of freedom for the prior.

The prior  $S$ , the variance-covariance matrix of  $A_t$ , is set to be

$$S_j \sim IW(\kappa_S^2 \times (j + 1) \times \Xi_{j,A}, j + 1) \quad j = 1, \dots, 3 \quad (97)$$

where  $S_1$  to  $S_3$  denote the blocks of  $S$ ,  $\Xi_{1,A}$  to  $\Xi_{3,A}$  denote the associated blocks of  $\Xi_A$  and  $\kappa_S = 0.1$  which is the same in Primiceri [2005]. All numbers for the priors such as  $\kappa_Q$ ,  $\kappa_W$  and  $\kappa_S$  are standard and consistent with Primiceri [2005].

---

<sup>70</sup>It does not seem that there is a consensus to set degrees of freedom for priors in TVP-VAR studies. Most TVP-VAR studies with full sample calibrated priors use the strategy that the degree of freedom is set to be the size of the vector  $B_{OLS} + 1$ , the minimum degree of freedom for the prior. However, in Canova and Ciccarelli [2009], they use the number which is approximately same with the sample size. In Koop et al. [2009], they stress out that the degrees of freedom which they choose is less than the size of the data though they use the training sample method.

## APPENDIX B

### TABLES AND FIGURES

Table 1. Explanatory Power of the Defence News Variable

State	Adj R-square	F-statistics	Marginal F-statistics	Number of Obs
Linear	0.1311	25.20	18.40	484
High debt	0.1871	15.57	8.92	193
Low debt	0.1348	15.59	15.97	291

*Notes:* The second and third column show statistics from a regression of log real per capita spending on current and four lags of the news variable (normalized by lagged GDP). The fourth column shows the joint significance of current and four lags of the news variable in a regression of log real per capita spending on a cubic trend, current and four lags of the news variable, and four lags of log real per capita spending, log real per capita GDP, log of real per capita debt, and nominal interest rate.

Table 2. Robustness: Different Time Trends, Thresholds, and Other Specification

	State	Cumulative multipliers					Difference	
		1year	2year	3year	4year	5year	1year	5year
35% Threshold	High	0.80	0.73	0.72	0.72	0.77		
	Low	1.27	0.90	1.21	1.36	1.77	-0.46	-1.12
60% Threshold	High	1.33	1.00	0.77	0.53	0.40		
	Low	0.51	0.62	0.71	0.76	0.82	0.81	-0.42
Quartic trend	Linear	0.73	0.76	0.82	0.85	0.94		
	High	0.98	0.82	0.71	0.60	0.57		
	Low	0.69	0.77	0.86	0.91	1.00	0.29	-0.44
Quadratic trend	Linear	0.68	0.69	0.75	0.78	0.85		
	High	0.95	0.67	0.52	0.38	0.21		
	Low	0.56	0.65	0.75	0.78	0.84	0.39	-0.63
First difference	Linear	0.56	0.63	0.70	0.72	0.77		
	High	1.01	0.85	0.80	0.78	0.82		
	Low	0.56	0.66	0.74	0.78	0.84	0.45	-0.02
Additional controls	Linear	0.70	0.70	0.68	0.77	0.85		
	High	1.26	1.18	0.75	0.80	0.82		
	Low	0.60	0.65	0.98	0.75	0.82	0.67	0.00
Exclude World War II	Linear	1.18	0.87	0.73	0.88	0.93		
	High	2.50	0.89	0.66	0.25	-0.04		
	Low	0.90	0.80	0.85	0.87	0.91	1.6	-0.95
Post World War II	Linear	0.72	0.57	0.57	0.41	0.50		
	High	0.88	0.45	0.19	-0.13	-0.37		
	Low	0.29	1.30	1.22	1.22	1.49	0.60	-1.85
Blanchard-Perotti	Linear	0.24	0.51	0.68	0.84	0.98		
	High	0.25	0.20	0.01	-0.24	-0.62		
	Low	0.37	0.70	0.86	0.96	1.12	-0.13	-1.73

*Notes:* ‘First difference’ means that the estimation with the first difference of the controls. ‘Additional controls’ means that the estimation with the controls in the baseline, unemployment, and credit spreads. ‘Excluding WWII’ indicates the results with the data excluding WWII (1939.Q3 to 1946.Q4). ‘Blanchard-Perotti’ indicates the results with Blanchard and Perotti [2002] method.

Table 3. Calibration

Description	Value	Parameter	Source
discount factor	0.99	$\beta$	standard RBC
risk aversion coefficient	1	$\sigma$	log utility
inverse Frisch elasticity	1	$\phi$	standard RBC
price stickiness	0.8	$\xi$	Gali et al. [2007a]
price elasticity of demand	11	$\epsilon$	Corsetti et al. [2012a]
production function	0.3	$\alpha$	Corsetti et al. [2012a]
	1.32	$\psi_{gg}^1$	estimation
government spending persistence	-0.18	$\psi_{gg}^2$	estimation
	-0.2	$\psi_{gg}^3$	estimation
responsiveness of spending to debt	0.2	$\psi_{gd}^H$	Corsetti et al. [2012a]
	0	$\psi_{gd}^L$	Corsetti et al. [2012a]
contemporaneous response of spending	0.01	$\psi_{gnews}^H$	estimation
	0.08	$\psi_{gnews}^L$	estimation
debt sensitivity of lump-sum tax	0.02	$\psi_{td}$	Corsetti et al. [2012a]
monetary policy	1.5	$\phi_\pi$	Gali et al. [2007a]
steady state G/Y	20%		Corsetti et al. [2012a]
threshold	45%		baseline estimation

Table 4. Data Source

Series	Source	Period
Gross federal government debt	Monthly statement of public debt	1890.Jan - 1937.Nov
	Treasury bulletin	1937.Dec - 2010.Dec
Real GDP, GDP deflator		
Nominal government spending	Owyang et al. [2013]	1890.1Q - 2010.4Q
news variable, population, unemployment		
10year government bond	Shiller [2005]	1890.Jan - 2010.Dec
Baa corporate bond	FRED	1919.Q1 - 2010.Q4
3-month treasury bill	FRED	1919.Q1 - 2010.Q4

*Notes:* Monthly statement of public finance: <http://www.treasuryhunt.gov/govt/reports/pd/mspd/mspd.htm>

Treasure bulletin: <http://fraser.stlouisfed.org/publication/?pid=407>.

Table 5. Detailed Data Source of US Gross Federal Debt

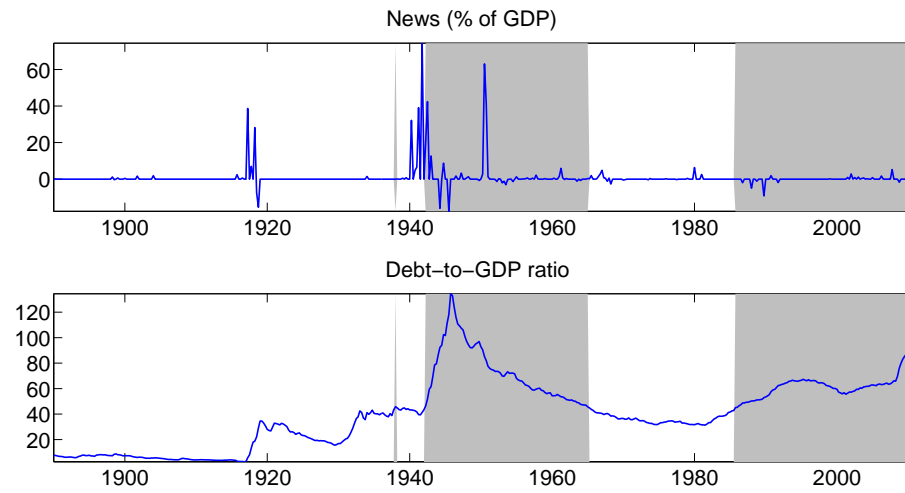
Period	Source
1890.Jan - 1937.Nov	Monthly statement of public debt(MSPD) : aggregate section(before 1915.Aug). gross debt section(after 1915.Aug).
1937.Dec - 1969.Sep	Treasury bulletin: table 1 in debt outstanding section and composition of debt table
1969.Dec - 2010.4Q	Treasury bulletin: FD-1 table

Table 6. Calibration

description	value	parameter	source
discount factor	0.99	$\beta$	standard RBC
risk aversion coefficient	1	$\gamma$	log utility
inverse Frisch elasticity	1	$\phi$	standard RBC
elasticity of trade price	0.7	$\sigma$	Monacelli et al. [2010]
price stickiness	0.75	$\xi$	Gali and Monacelli [2005]
price elasticity of demand	11	$\epsilon$	Corsetti et al. [2011]
import share	0.2	$\omega$	Data
monetary policy	1.5	$\phi_\pi$	Gali and Monacelli [2005]
debt elasticity of interest rate	0.00001	$\chi$	Corsetti et al. [2009]
non-asset holder	1/3(1/2)	$\lambda$	Born et al. [2013b]
government spending persistence	0.9	$\psi_{gg}$	Born et al. [2013b]
debt elasticity of spending	0(-0.05)	$\psi_{gd}$	Gali et al. [2007b]
tax finance	0.5(0)	$\psi_{tg}$	Corsetti et al. [2009]
debt elasticity of taxes	0.02	$\psi_{td}$	Corsetti et al. [2011]
steady state G/Y	0.2		Data

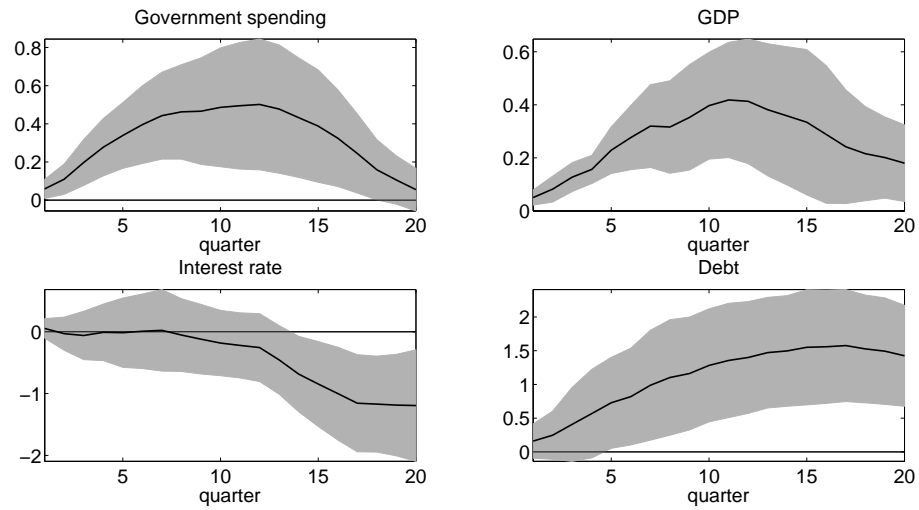


Figure 1. Debt-to-GDP Ratio and News Variable



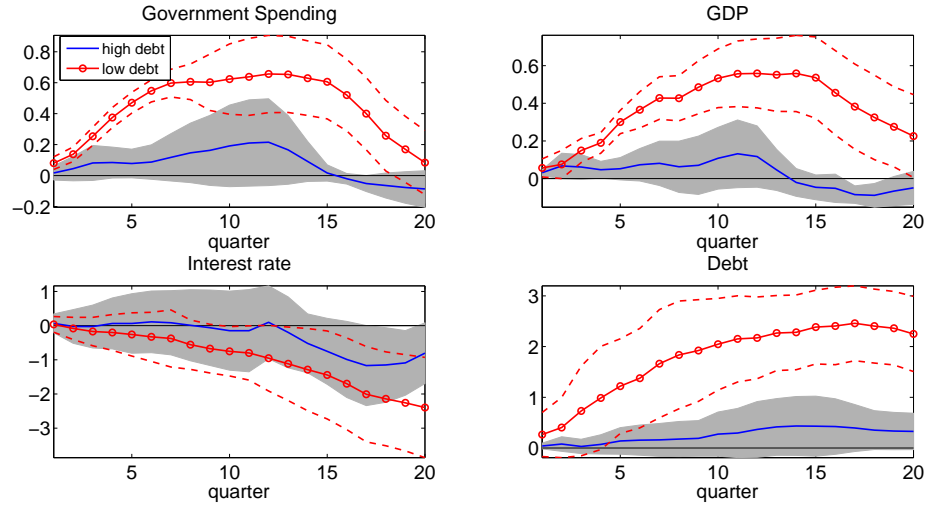
*Notes:* Shaded areas indicate that the debt-to-GDP ratio exceeds 45%.

Figure 2. Impulse Response in the Linear Model



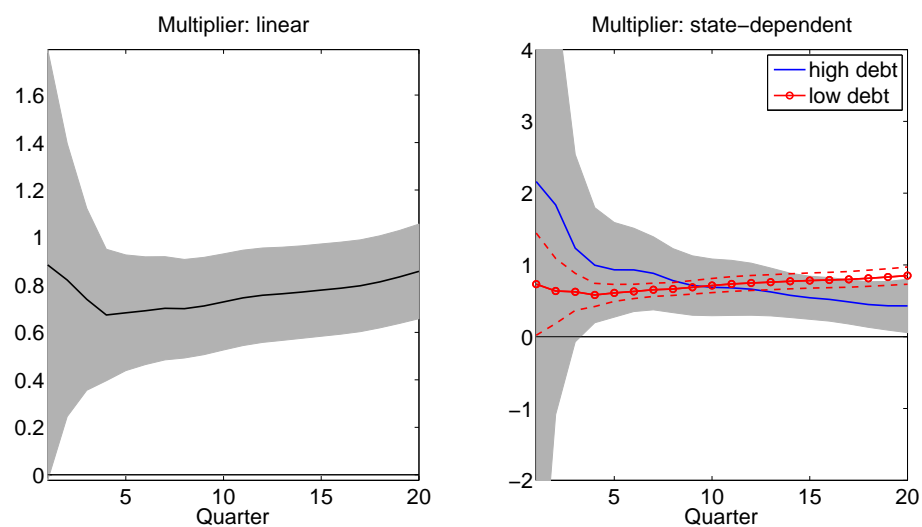
*Notes:* Shaded areas indicate the associated 95% confidence interval. The response of government spending is measured in percentage of GDP. The responses of GDP and debt are measured in percentage deviations. The response of interest rate is measured in basis points.

Figure 3. State-dependent Impulse Response



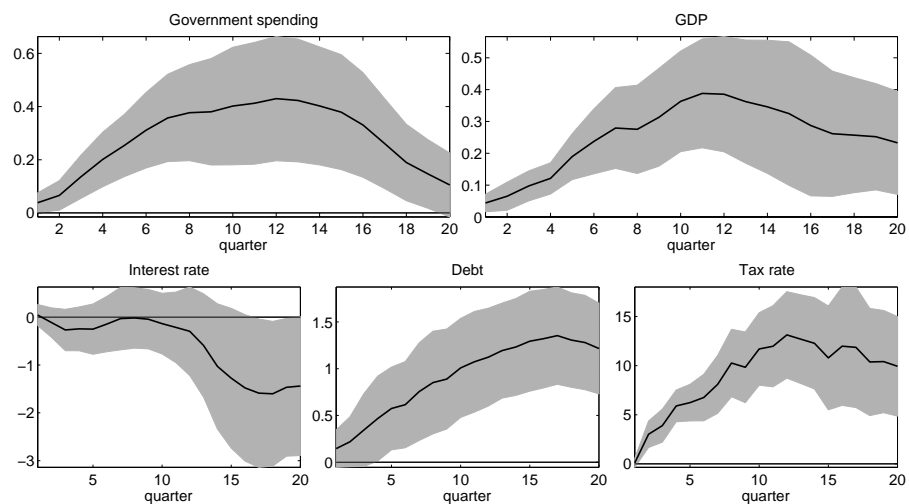
*Notes:* Blue solid lines and lines with circle are the response in a high debt state and a low debt state, respectively. Shaded areas and dotted lines are the associated 95% confidence interval. Changes in variables are measured in the same unit as in figure .

Figure 4. Cumulative Multipliers



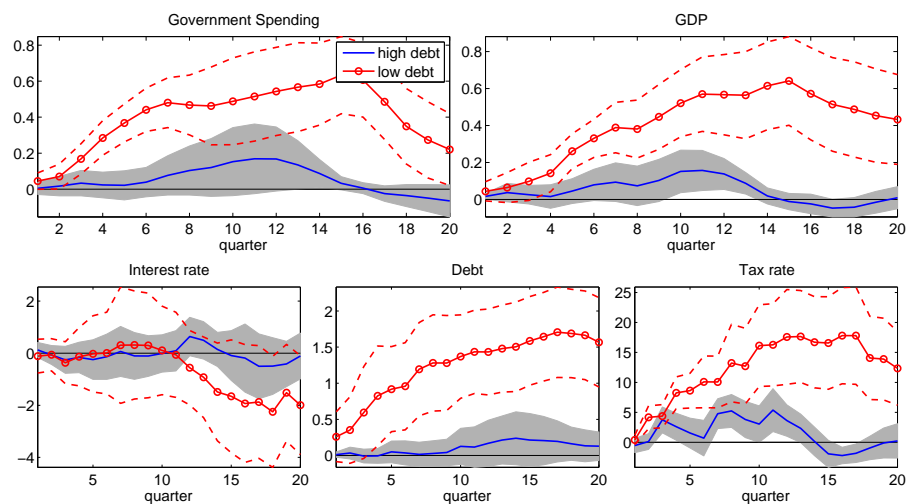
*Notes:* The panel is the cumulative multipliers in the linear model and the state dependent model, respectively. 95% confidence intervals are reported.

Figure 5. Impulse Response in the Linear Model with Tax Rates



*Notes:* Shaded areas indicate 95% confidence interval. The response of government spending is measured in percentage of GDP. The responses of GDP and debt are measured in percentage deviations. The responses of interest rate and tax rate are measured in basis points.

Figure 6. State-dependent Impulse Response with Tax Rates



*Notes:* Blue solid lines and lines with circle are the response in a high debt state and a low debt state, respectively. Shaded regions and dotted lines are the associated 95% confidence interval. Changes in variables are measured in the same unit as in figure .

Figure 7. The Ratio of Cumulative Tax Receipts to Cumulative Government  
Spending

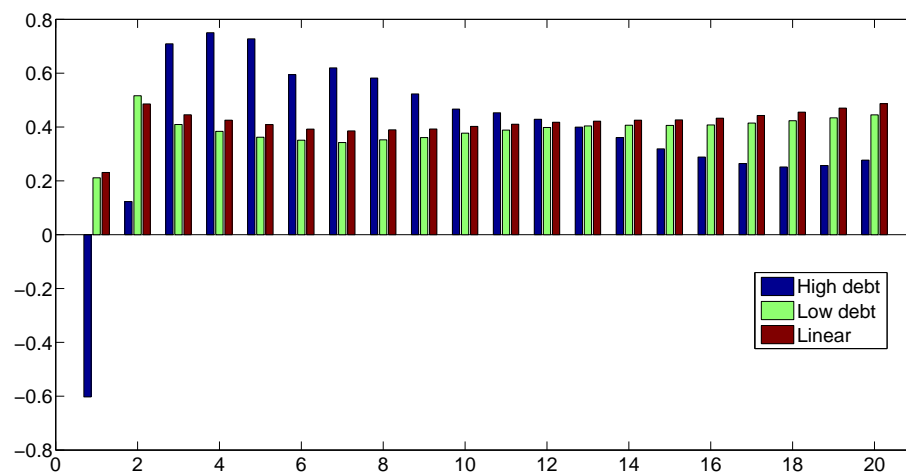
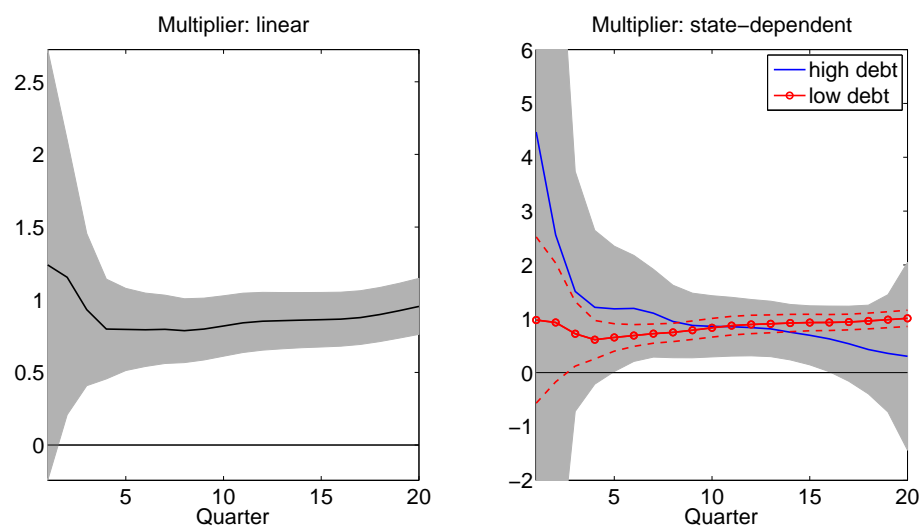


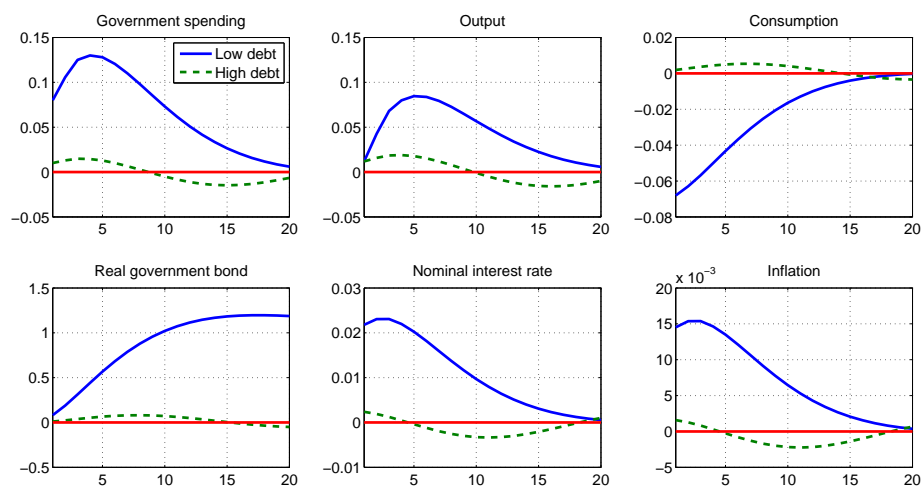
Figure 8. Cumulative Multipliers



*Notes:* The panel is the cumulative multipliers in the linear model, in a low debt state, and in a high debt state, respectively. 95% confidence intervals are reported.

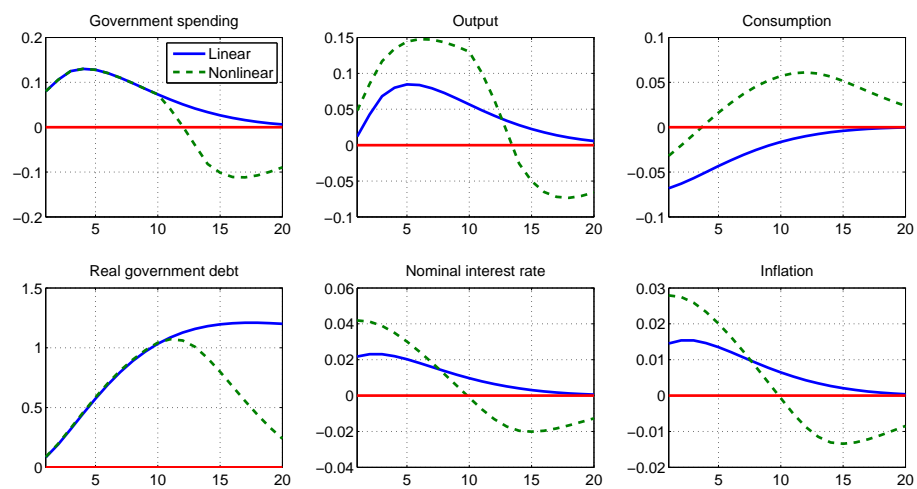


Figure 9. Selected Impulse Responses to a Defense News Shock



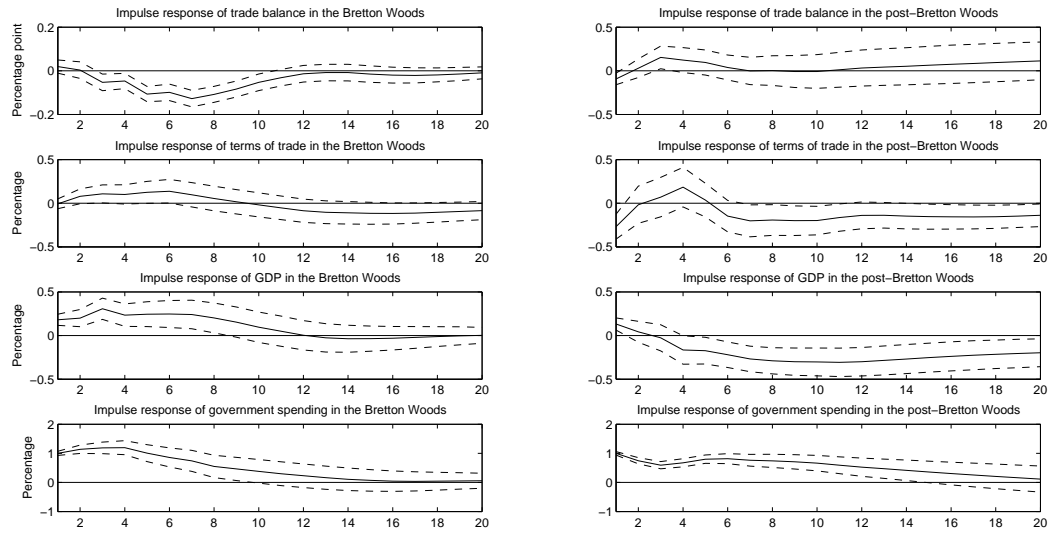
*Notes:* Quantities are measured in deviations from the steady state normalized by steady state output. Interest rate and inflation are measured in % deviations from the steady state.

Figure 10. Selected Impulse Responses to a Defense News Shock: Non-linear



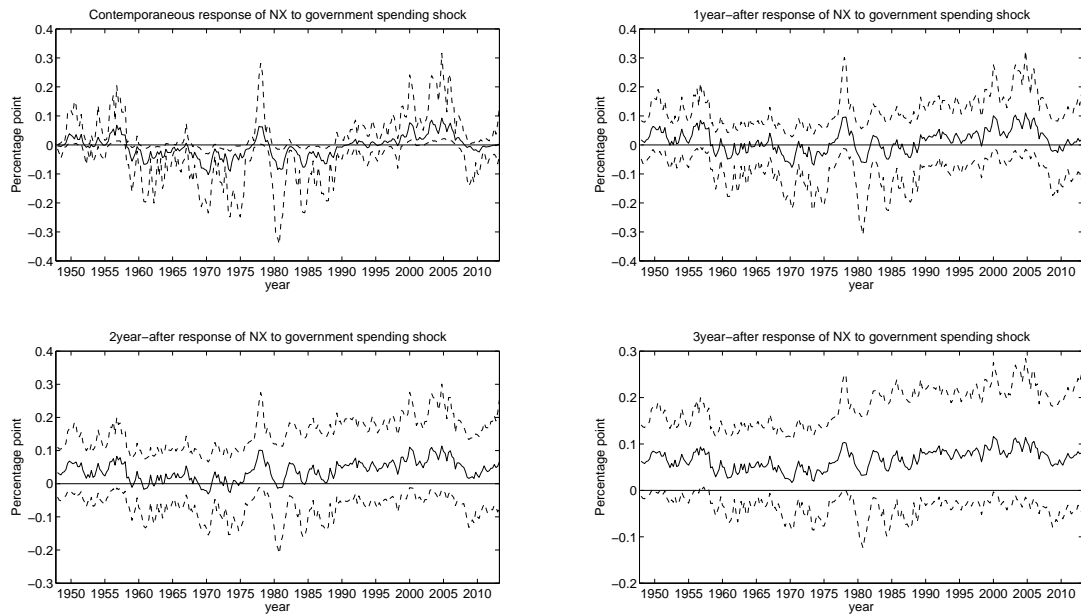
*Notes* Quantities are measured in deviations from the steady state normalized by steady state output. Interest rate and inflation are measured in % deviations from the steady state.

Figure 11. Impulse Response of Selected Variables in Sub-sample VAR



Notes Dotted line is the one-standard deviation error band

Figure 12. Median Response of NX to Government Spending



*Notes* Solid line is the median response and dotted line is the 68% confidence band.

Figure 13. Median Response of NX to Government Spending: 3D-plot

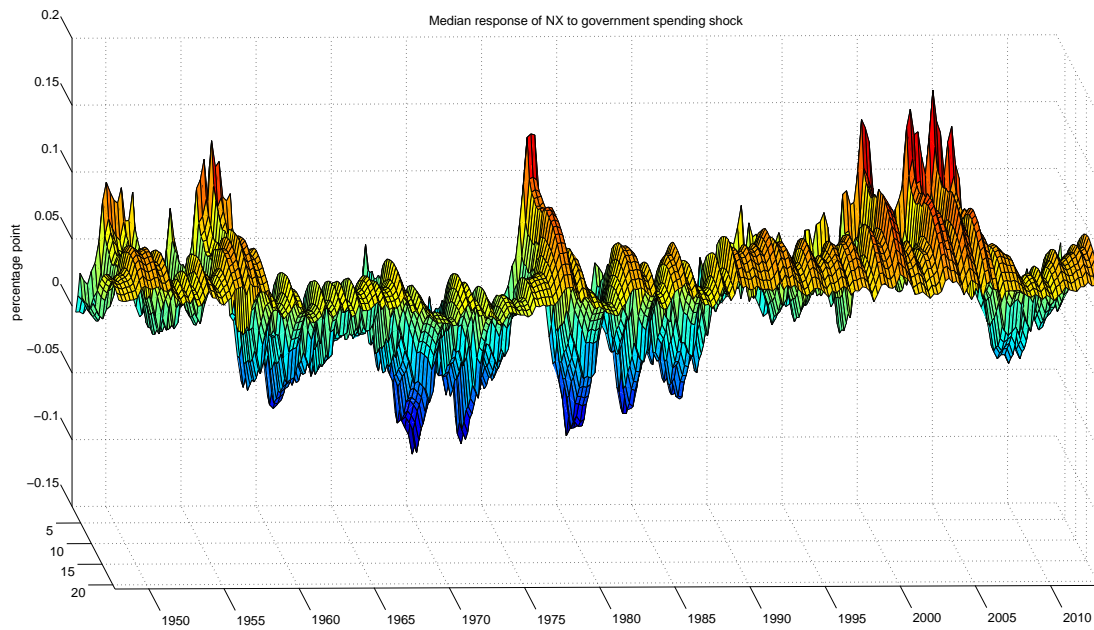
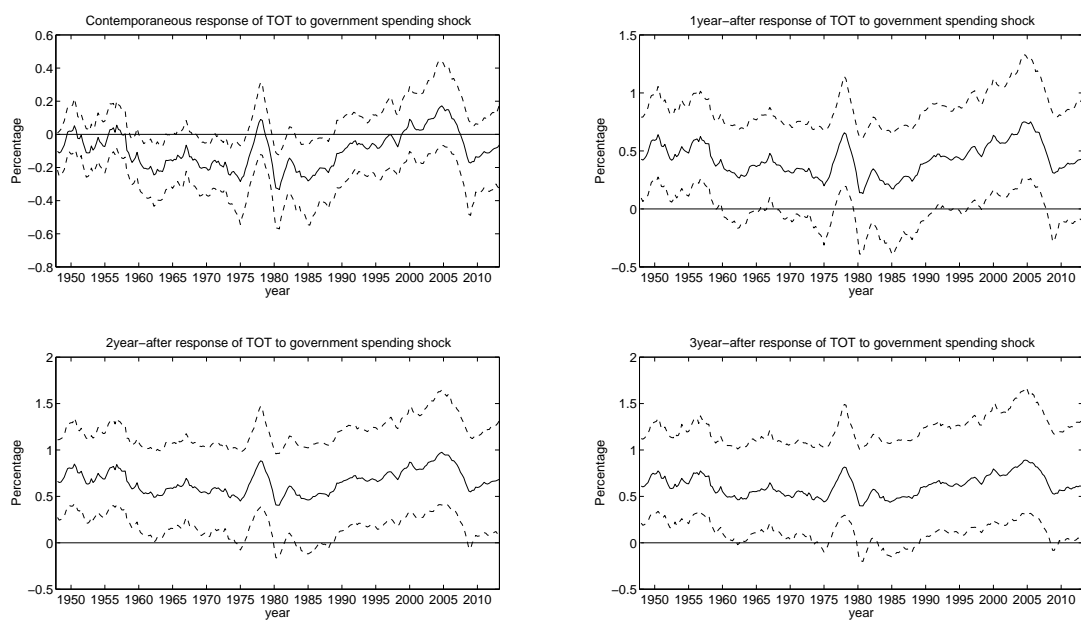


Figure 14. Median Response of Terms-of-trade to Government Spending



*Notes* Solid line is the median response and dotted line is the 68% confidence band.

Figure 15. Median Response of Terms-of-trade to Government Spending: 3D-plot

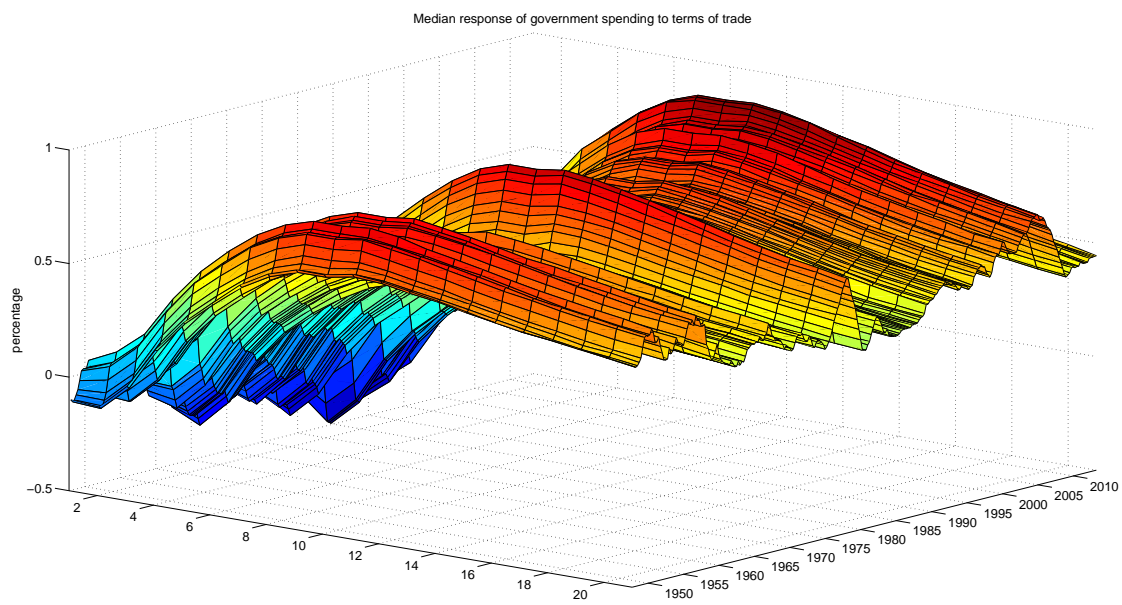
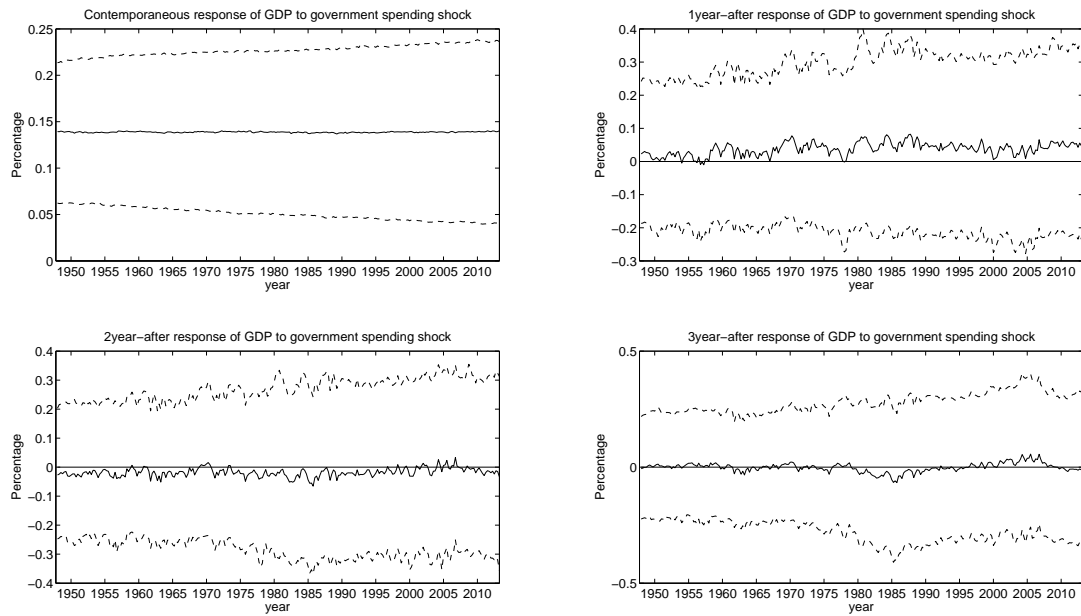


Figure 16. Median Response of GDP to Government Spending



*Notes* Solid line is the median response and dotted line is the 68% confidence band.



Figure 17. Median Response of GDP to Government Spending: 3D-plot

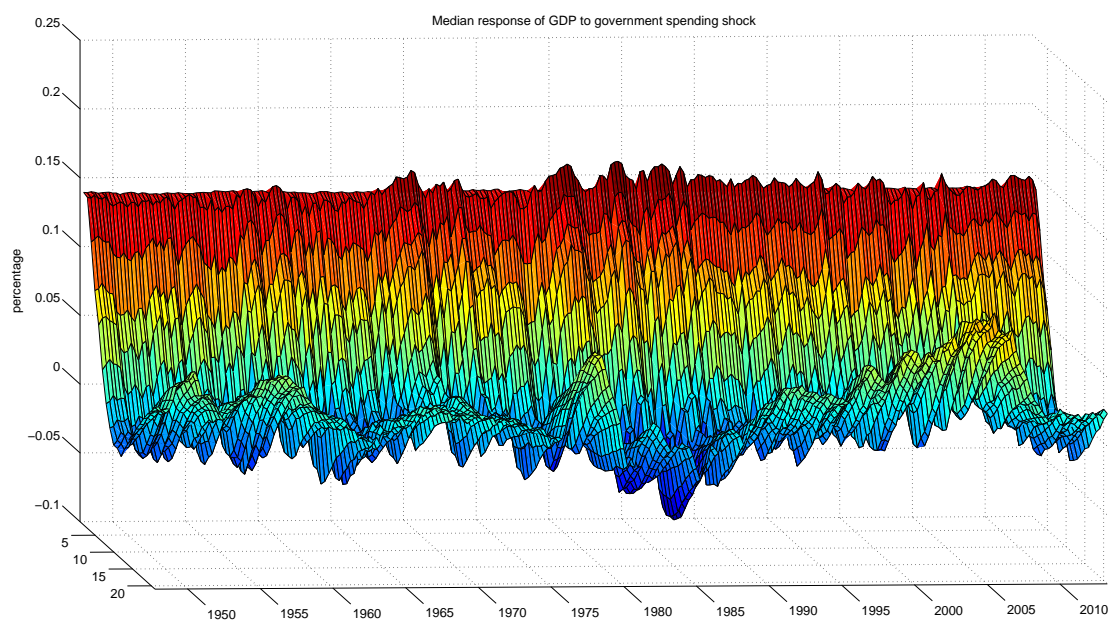
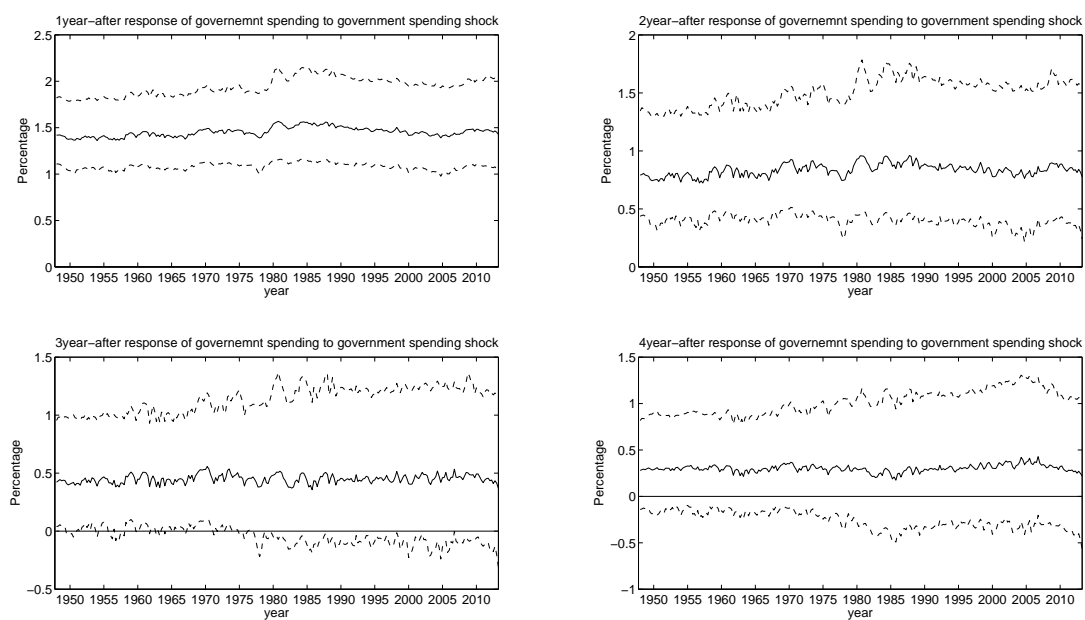


Figure 18. Median Response of Government Spending to Government Spending



*Notes* Solid line is the median response and dotted line is the 68% confidence band.

Figure 19. Median Response of Government Spending to Government Spending:  
3D-plot

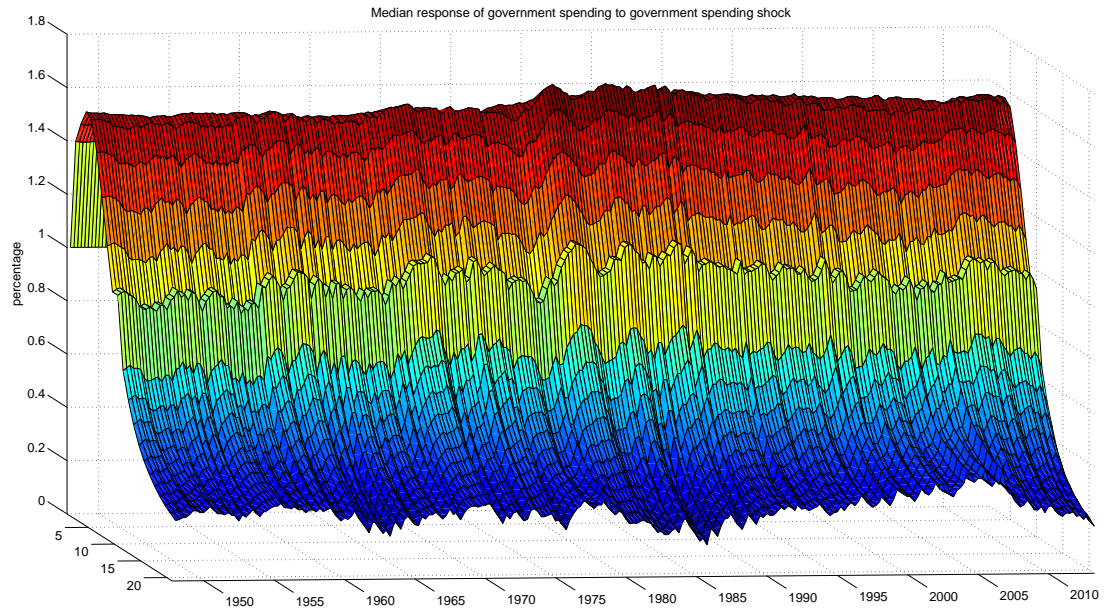


Figure 20. Impulse Response of Selected Variables to Government Spending Shock  
under Different Exchange Rate Regime

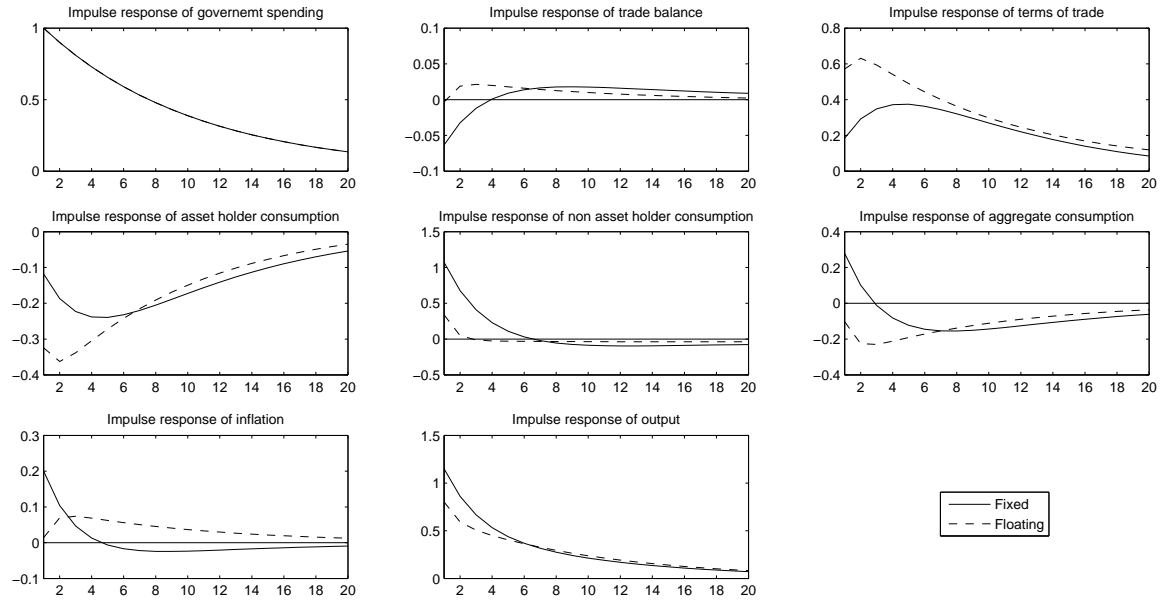


Figure 21. Impulse Response of Selected Variables to Government Spending Shock  
with Slow Adjusting Taxes

